DISPERSION AND POPULATION ESTIMATION OF

TABANUS ABACTOR PHILIP

(DIPTERA: TABANIDAE)

IN NORTHCENTRAL

OKLAHOMA

By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Tabanids (Diptera: Tabanidae) are among the most important economic pests of livestock in North America and other regions of the world. These flies are noted for their aggressive feeding behavior which often results in general annoyance, considerable blood loss, mechanical disease transmission, reduced weight gain and reduced milk production in cattle.

Over 65 species of tabanids have been reported in Oklahoma with the most prevalent species of the northcentral region of the state being *Tabanus abactor* Philip. This species is the most important pest of cattle from mid-June to late August and imbibes an average blood meal of ca. 150 mg, in excess of over two times its own body weight (Hollander and Wright 1980a). Thus this species causes significant blood loss, considerable host discomfort and irritation which causes excessive energy expenditure by the host.

The potential of tabanids to mechanically transmit pathogenic disease agents is greatly enhanced by the erratic feeding behavior and frequent transfer between hosts. *Tabanus abactor* has been determined to transmit the causative agent of anaplasmosis, *Anaplasma marginale* (Sanborn et al. 1932). This species may also be capable of mechanically transmitting *Bacillus anthrasis* (anthrax), hog cholera and equine infectious anemia viruses since the transmission of these organisms has been associated with other tabanid species (Krinsky 1976).

Steelman (1976) estimated that tabanids caused losses in excess of $40 million annually to the cattle industry. Studies by Roberts and Pund (1974) revealed that steers sprayed to deter the attack of biting flies, including tabanids, gained ca. 0.2 lbs more per day than control animals. Recent economic impact studies indicate that animals stressed with large populations of tabanids in Oklahoma gained 0.2 lbs less per day than animals protected from tabanids (Perich and Wright unpublished data). Bruce and Decker (1951) and Garnett and Hansens (1956) found that tabanid annoyance caused reduced milk production in dairy cattle.

Presently there are no effective control methods for tabanids. Current research efforts with various insecticides show some permethrin formulations may aid in reducing tabanid numbers on cattle (Presley and Wright unpublished data). However, relatively little information is known regarding the biology, behavior and population dynamics of prevalent pest species of range cattle in Oklahoma. Knowledge in these areas is an important factor for planning effective control programs in the future. Therefore, the primary objectives of this study were to determine the flight range, dispersal rate and distance, habitat preference and to estimate population size of T. abactor in northcentral Oklahoma. A mark-recapture technique was used to evaluate these parameters.

CHAPTER II

REVIEW OF LITERATURE

Distribution

Tabanus abactor was first described by Philip (1936) from specimens collected in several Texas counties. Schomberg and Howell (1955) reported this species in parts of Oklahoma, Arkansas and Kansas. Davis and Sanders (1981) found that *T. abactor* constituted 98% of the population of all tabanid species in the Texas Rolling Plains. This species has also been listed as occurring in the southwestern counties of Missouri (Andrews and Wingo 1975) but has not been reported in Louisiana (Tidwell 1973). Hollander and Wright (1980b) and Wright et al. (1984) reported that *T. abactor* comprised 50% or more of the tabanid population in northcentral Oklahoma, while Ehrhardt (1981) found that this species comprised less than 3% of the population in LeFlore County in southeast Oklahoma. *Tabanus abactor* has been reported in all of Oklahoma east of the panhandle (Wright and Whittle unpublished data).

Flight Range and Dispersal

Few aspects of the dispersal activity and flight range of Tabanidae have been determined. *Hybomitra affinis* (Kirby) was calculated to have a theoretical flight range of 91 km and a maximum flight endurance of 16 hr (Hocking 1953). Various *Chrysops* and *Tabanus* species were trapped at distances of 3.2 to 8.4 mi from land on Delaware Bay by MacCreary

(1940), but Jamnback and Wall (1959) concluded that these flies were probably carried these distances by boats. *Tabanus nigrovittatus* Macquart, a salt marsh species, appears to fly no farther than ca. 1 mi offshore (MacCreary 1940; Jamnback and Wall 1959). Studies in Nigeria with *C. dimidiata* van der Wulp and *C. silacea* Austen indicate these species have a flight range of ca. 1200 yds but that they usually fly shorter distances (Davey and O'Rourke 1951). *Tabanus iyoensis* Shiraki, a Japanese species, has been estimated to have a dispersal rate of 130 m per day (Inoue et al. 1973).

Mark-Recapture Studies

Numerous studies have shown mark-recapture methods to be highly successful for evaluating the dispersal and flight range of various medical and veterinary important Diptera. Information concerning the flight habits of the house fly, *Musca domestica* L., has been gathered by utilization of mark-recapture procedures (Lindquist et al. 1951; Morris and Hansen 1966; Pickens et al. 1967; Quarterman et al. 1954; Schoof et al. 1952). Mark-recapture methods have also been used to establish flight movements of the horn fly, *Haematobia irritans* L. (Chamberlain 1981, 1982; Eddy et al. 1962; Hoelscher et al. 1968; Kinzer and Reeves 1974; Tugwell et al. 1966), face fly, *Musca autumnalis* DeGeer (Turner and Gerhardt 1965; Killough et al. 1965), stable fly, *Stomoxys calcitrans* L. (Berry et al. 1981), and several mosquito species (Jenkins and Hassett 1957; Provost 1952; Reisen and Mahmood 1981).

Relatively few studies using mark-recapture techniques have been used to monitor the flight ranges and dispersal of Tabanidae. Thornhill and Hays (1972) utilized mark-recapture techniques to determine dispersal and flight activities of several tabanid species in Alabama and found that 70% of the recaptured flies occurred within 0.5 mi of the release point. They indicated that the majority of the recaptured flies were smaller species suggesting that the larger, robust species may have flown greater distances. Sheppard and Wilson (1976) investigated the flight range of tabanids in a Louisiana bottomland forest and recaptured Chrysops and Tabanus species from distances of 0.8 to 6.8 km from release points. Inoue et al. (1973) used a quantitative analysis of the dispersal of T. iyoensis in Japan and found that dispersal was of two types: general host-seeking and directive movement by pursuing moving vehicles. They concluded that on the average, a marked fly would disperse a distance of 1.2 km in eight days after release but that the average distance at which marked flies died was 340 m from the release site.

Previous mark-recapture studies in Oklahoma by Ehrhardt (1981) and Wright (unpublished data) were used to determine the frequency of feeding tabanids but did not specifically measure flight range. Foil (1983) used a mark-recapture technique to predict the spatial barriers required to lower the potential for mechanical transmission of anaplasmosis by tabanids transferring between hosts.

Marking Methods

Various marking techniques have been used in mark-recapture studies but the success of such studies is dependent upon the effectiveness of the marking method. Ideal requirements for marking materials have been outlined by Bennett et al. (1981) and Chamberlain et al. (1977): marks should (1) be easily detected in the field; (2) be permanent for the life of the individuals; (3) not alter the behavior or survivorship of the marked subject; (4) be capable of being applied in many different codes to individuals _en masse_.

Three basic marking techniques have been used for Diptera: radioactive isotopes, fluorescent dusts and enamel paints. Radioactive isotopes have been utilized for mark-recapture studies of house flies (Lindquist et al. 1951; Eddy et al. 1962), mosquitoes (Yates et al. 1951), stable flies and horn flies (Eddy et al. 1962). Major disadvantages of radioactive isotopes are that their use often requires the destruction of the specimens and the utilization of special equipment to determine the presence of the marking isotope. This method works best when the isotope is incorporated into the diet of the individuals. Bennett and Smith (1968) used phosphorous^{32} to mark tabanids for population studies by allowing the flies to imbibe the isotope in water droplets. However, the inability to successfully rear most Tabanidae and induce feeding in wild flies in the laboratory poses a major problem with this method as does the difficulty in quantifying the amount of isotope imbibed and its decay rate.

Fluorescent powders or dusts are considered to be superior marking substances as they can be easily detected on live specimens, large numbers of individuals can be rapidly marked and numerous color combinations can be achieved (Bennett et al. 1981). Chamberlain et al. (1977) determined Day Glo® fluorescent pigments to be the most satisfactory of several micronized fluorescent powders evaluated for marking horn flies. They found that the pigments adhered better when dissolved in acetone and applied uniformily by spraying. This technique has been used successfully for marking horn flies (Chamberlain 1981) and stable flies (Berry et al. 1981) with no adverse effects. Kinzer and Reeves

(1974) have also used Day Glo® pigments for marking horn flies but their method is not described.

Fluorescent dusts have been used to mark Tabanidae by allowing flies to mark themselves as they pass through a trap top (Sheppard et al. 1973, 1980; Harlan and Roberts 1976). The disadvantages of this method include lack of control of the intensity of the mark and of the exact number of flies marked. Disadvantages of fluorescent dusts in general are the loss of pigment with time making recognition of marked individuals difficult, possible transfer of pigment from marked to unmarked specimens in trap tops and requirement of an ultra violet light source for positive identification.

Enamel paints applied by hand to the dorsum of the thorax of tabanids have proved to be a satisfactory marking method (McDonald 1977; Thornhill and Hays 1972; Ehrhardt 1981; Foil 1983; Wright unpublished data). Beesley and Crewe (1963) concluded that enamel paint on the thorax of _C. silacea_ had no significant effect on the flies. Although this procedure is limited to marking small populations since it is rather time consuming, it has the advantage that the marks can be easily detected by the unaided eye in both field and laboratory situations. The paints are available in many colors and can be easily mixed to produce additional shades.

Trapping Methods

Modifications of Townes' Malaise trap have been determined to be the most efficient for trapping tabanids (Roberts 1971). Roberts (1976) reported that a modified version, the Stoneville trap, constructed of natural saran screen and baited with a source of CO_2 would collect more tabanids than any other type of trap. This trap has been used for tabanid studies in Oklahoma with satisfactory results (Hollander 1979; Ehrhardt 1981; Wright et al. 1984).

Methods of Estimating Populations

Several methods of estimating animal population size or density from mark-recapture data have been developed. Southwood (1978) has reviewed several of the most accepted approaches for analyzing mark-recapture data. The most common and simplistic method is that of the Lincoln Index (Lincoln 1930): $\hat{N} = \frac{an}{r}$ where $\hat{N}$ = population estimation, a = number of individuals marked, n = number of wild and marked individuals of the second sample and r = number of recaptures in the sample. The Lincoln Index is the basis from which most mark-recapture models and analysis have been derived. However, regardless of the simplicity or complexity of the model, several assumptions underlie all methods of mark-recapture analysis (Southwood 1978):

1. Marked individuals are not affected by the mark either in life expectancy or behavior.
2. Marked individuals mix completely with the population.
3. The probability of capturing a marked individual is the same as any other member of the population.
4. Sampling is at discrete time intervals.
5. The population is closed, or immigration and emigration can be accounted for.
6. Birth and death rate must be accounted for in the periods between sampling.

If these basic assumptions are met for the Lincoln Index, then other population characteristics such as the degree of mobility of the insect, length of sampling period, survivability or feeding frequency can be evaluated to determine what modifications can be applied to the Index to improve its fit to the population being estimated.

The Fisher-Ford (1947) model is based on the Lincoln Index and is applicable to flies released on two or more occassions with allowance for loss of marked individuals between the time of initial release and sampling. The method is actually a series of the Index estimates in reverse: $\hat{N}t = \frac{n_t a_i \phi_{i-t}}{r_{ti}}$ where $\hat{N}t$ = population estimate, n_t = total sample at $time_t$, a_i = total marked insects at $time_i$, ϕ_{i-t} = survival rate over $period_{i-t}$, and r_{ti} = recaptures at $time_t$ of insects marked at $time_i$. A distinct advantage of this model is that it has the ability to incorporate periodicity of availability; for example the periodic blood feeding of some dipterans. This approach has been successfully used to estimate populations of the mosquito Aedes aegypti (L.), which has a four day feeding cycle (Conway et al. 1974; Sheppard et al. 1969).

Inoue et al. (1973) estimated populations of T. iyoensis using the stochastic model of Jolly (1965). The basic equation of Jolly's method is: $\hat{N}_i = \frac{\mu_i n_i}{r_i}$ where $\hat{N}_i$ = estimate of population on day_i, μ_i = estimate of the total number of marked animals surviving on day_i, n_i = total captured on day_i and r_i = total number of recaptured animals on day_i. This method can be extended to cover situations in which there is both loss and dilution of the population as well as allowing for any individuals killed after recapture and not released again (Southwood 1978). Inoue et al. (1973) derived a modification of Jolly's method and estimated an apparent survival rate which accounts for little contribution of old marks after a given survival period which contrasts with Jolly's (1965) real survival rate which assumes that age does not affect the survival rate.

Populations of tabanids in Mississippi were estimated by Harlan and Roberts (1976) using adaptations of the formulae of Jolly (1965) and

Inoue et al. (1973). Their formula for estimation of female tabanid populations was:

$$\frac{\text{No. Marked}}{\text{No. Recovered}} = \frac{\text{Total No. } \female \text{ Tabanids}}{\text{Total Marked and Unmarked Trapped Tabanids}}.$$

The number of tabanids marked each day was multiplied by a determined daily survival factor with each day's survival added to the next day's total number of marked flies and the number of recaptured flies subtracted to obtain the number of marked flies in the population on that day (Harlan and Roberts 1976). This number was used as the number marked in their formula. This method of estimating host-seeking populations of tabanids appears to be a reasonable approach to estimating populations of _T. abactor_ since it involves the use of population parameters that are easily determined for this species in view of the fact that very little is known about many aspects of the biology and behavior of _T. abactor_.

CHAPTER III

MATERIALS AND METHODS

Location

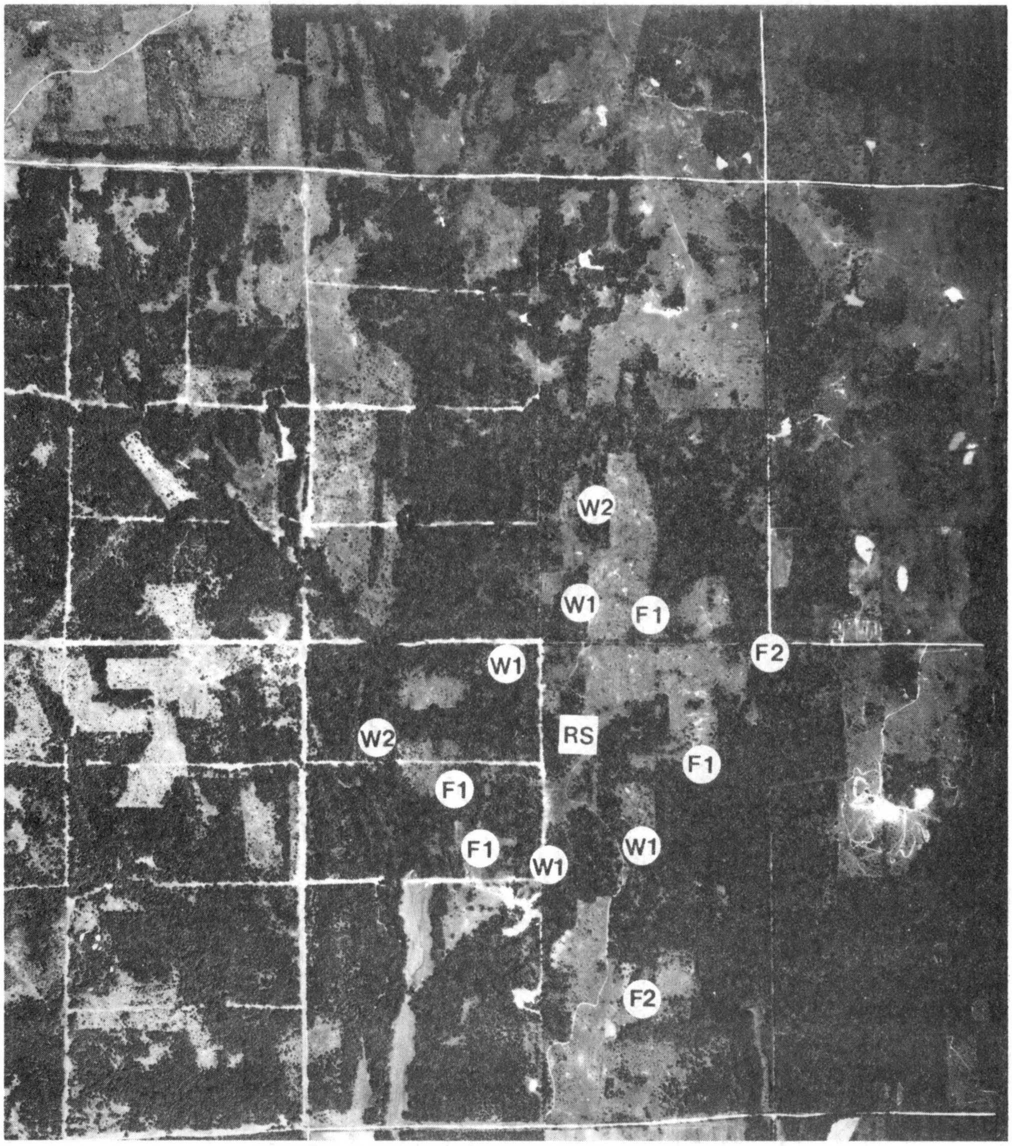
All aspects of this study were carried out at the Oklahoma State University Entomology Pasture 2 and adjacent Agronomy/Animal Science Cross Timbers Experimental Range located ca. 11 km southwest of Stillwater in Payne County, Oklahoma. The trapping area was composed of ca. 60% upland forest dominated by *Quercus marilandica* (blackjack) and *Q. stellata* (post oak) and ca. 40% tall grass prairie of *Panicum oligosanthus* (Rossette panicgrass), *Andropogon scoparius* (little bluestem) and *Sorghastrum nutans* (Indian grass) (Ewing et al. 1984).

Trap Placement

In 1982, 12 modified Stoneville Malaise traps were placed in a circular pattern in a 2.1 km^2 area at distances of 0.4 km (8 traps) and 0.8 km (4 traps) from a central release site (Figure 1). The trapping arrangement was designed to determine if dispersal was random and also if *T. abactor* showed a preference for woods' edge or open field habitats. Four traps were placed in each habitat at 0.4 km and two traps were placed in each habitat at 0.8 km.

In 1983, 20 traps were placed in a semi-circular pattern in a 8.2 km^2 area at the woods' edge at distances of 0.4 km (3 traps), 0.8 km (3 traps), 1.2 km (4 traps), 1.6 km (7 traps) and 2.4 km (3 traps) from

Figure 1. Arrangement of Malaise traps in woods' edge and open field habitats of the Cross Timbers Experimental Range in Payne County, Oklahoma in 1982.



1982
1-0.4 km
2-0.8 km
W-WOODS' EDGE
F-OPEN FIELD
RS-RELEASE SITE

6
7 4
8 5
10 RS 3
9
11 12 2
1

the release site. This trapping arrangement was designed to monitor flight range and speed. Except for two traps located at 0.4 km south of the release site, the other 18 traps were located in a semi-circle E, N and W of the release site to prevent the presence of cattle on private pastures in the SW, S and SE areas from competing with the traps for marked recaptures and total specimens trapped (Figure 2).

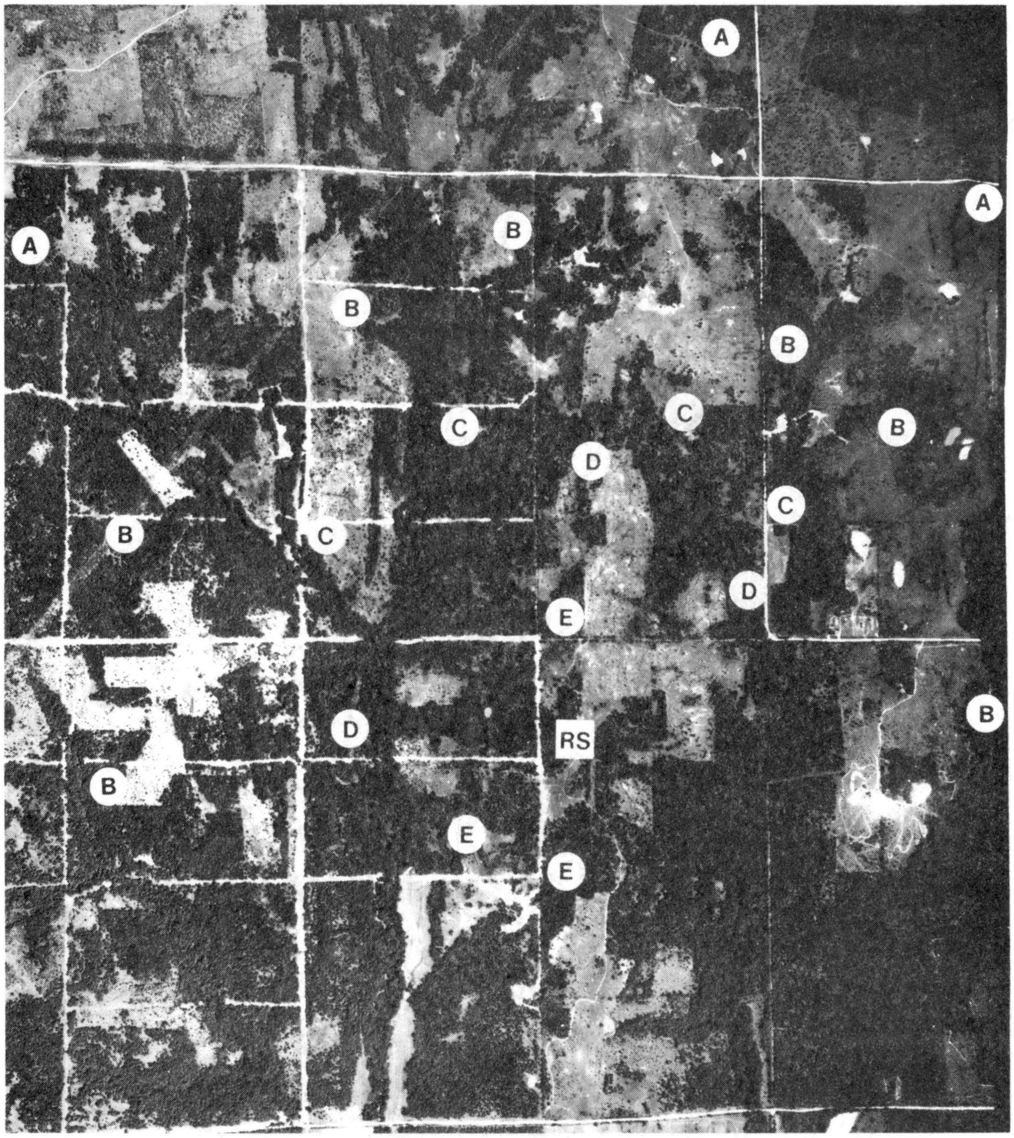
Marking Technique

Two groups of *T. abactor*, engorged and nonengorged, were marked since the host-seeking activity and thus the dispersal activities for each group would differ. *Tabanus abactor* has been shown to take an additional blood meal at 72-96 hr after a previous blood meal (Wright unpublished data) and therefore engorged specimens would not be seeking a host immediately after release. Engorged flies were marked to determine if there was a tendency for them to remain in an area where a previous blood meal had been taken and to determine if dispersal patterns were similar to that of the released nonengorged flies once the blood meal was digested. Nonengorged flies were marked to determine immediate dispersal rate and distance since this group would be actively seeking a host upon release.

Marking of Engorged Flies

Flies to be released as engorged individuals were allowed to land and initiate feeding on three to five tame dairy cattle tethered at the release site. Once the flies began engorgement they were individually marked on the dorsum of the thorax with a small dot of Testor's® enamel paint applied with a camel's-hair brush (Figure 3). This marking

Figure 2. Arrangement of Malaise traps in woods' edge habitat of the Cross Timbers Experimental Range in Payne County, Oklahoma in 1983.



1983
A-2.4 km
B-1.6 km
C-1.2 km
D-0.8 km
E-0.4 km
RS-RELEASE SITE

11
5
17
20 16
4
15 9 10 3
2
19 14
8
7
1
13 RS
18
12 6

Figure 3. Marking of engorged <u>Tabanus abactor</u> on foreleg of cow.

technique did not appear to disturb the flies if engorgement had begun prior to marking. Each mark day was denoted by a different color of paint. Flies were allowed to disperse at will upon completion of the blood meal (Figure 4). Generally engorged flies were marked 2-3 days in succession of the release site.

Marking of Nonengorged Flies

Nonengorged flies were collected at a site ca. 0.8 km south of the release site to prevent recapture of previously marked engorged flies that might be returning for an additional blood meal in ca. 72 hr. Flies were allowed to land on tethered dairy cattle, at which time they were removed from the animals by placing a plastic pill cup over them and then sliding a paper lid on the cup (Figure 5). The cups with the captured flies were placed in ice filled chests to immobilize the flies (Figure 6). Upon immobilization (ca. 20 min), the flies were marked on the thorax with enamel paint. The flies were then transferred to screen release cages (Figure 7) stored within a plastic Gott® ice chest with freezer packs in the lid to reduce activity until release. This did not fully immobilize the flies as did placing them on ice but prevented excessive movement and wing damage.

The flies were transported to the central release site in the release cages where the cages were placed on plastic sheets to facilitate recovery of any dead flies following release. The flies were allowed to disperse from opened cages. At ca. 12 hr, all dead flies were counted and the number was deducted from the original release number.

Initially, several releases were attempted per mark day for the nonengorged flies. This was later reduced to ca. two releases made near

Figure 4. _Tabanus_ _abactor_ marked on dorsum of thorax with enamel paint.

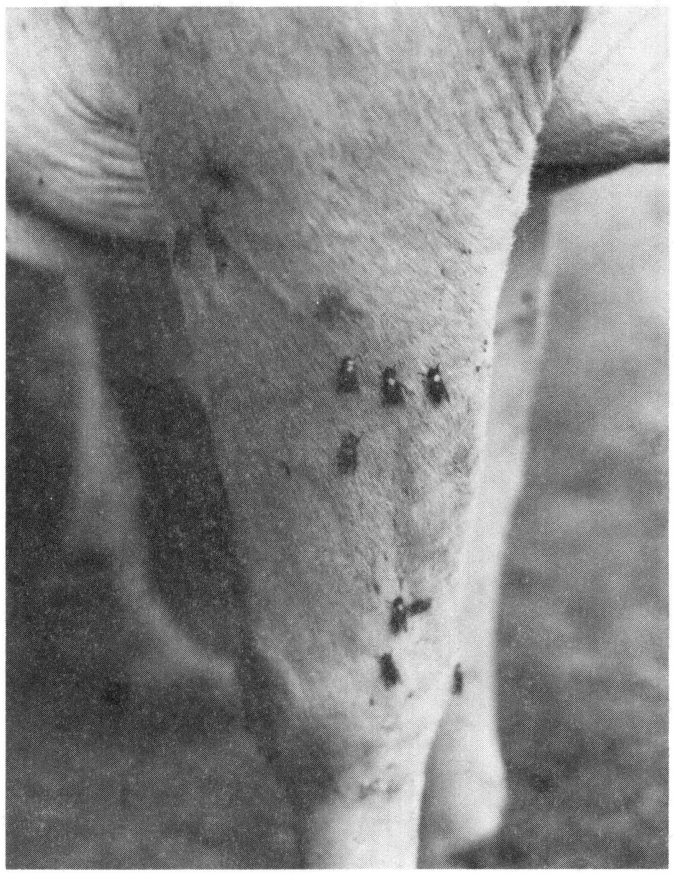


Figure 5. Collection of nonengorged *T. abactor* with plastic pill cup.

Figure 6. Chilling of nonengorged *T. abactor* prior to marking.

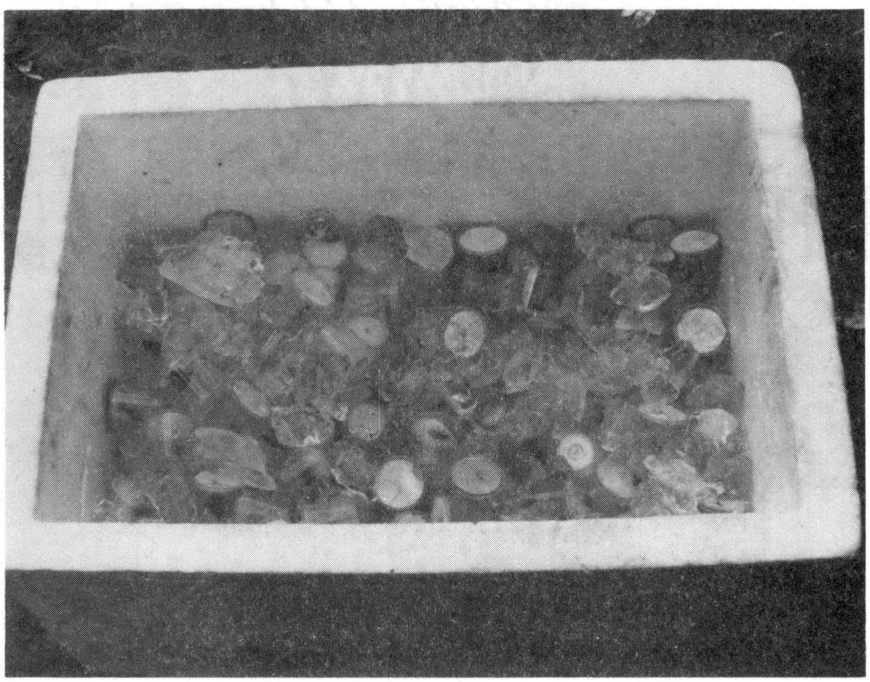
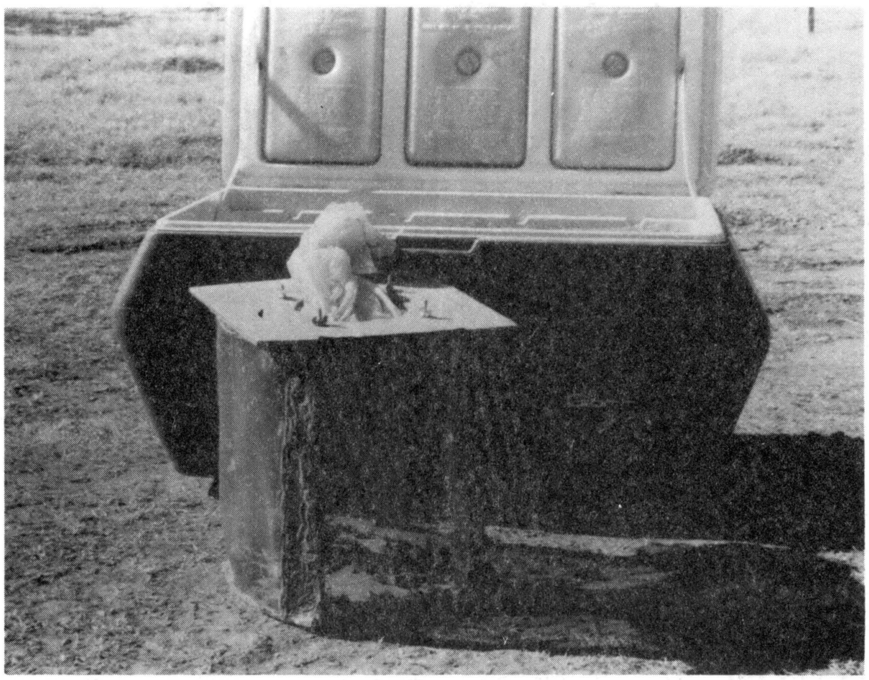


Figure 7. Screen release cages and cooler used for holding marked nonengorged *T. abactor* prior to release.



dusk which allowed for all marked flies to disperse at the same time, presumably at dawn the following day. This release schedule also reduced the chance of attracting marked flies away from the release site with vehicles.

The use of fluorescent dusts was attempted for marking nonengorged flies in 1982. The flies were placed in release cages after capture and sprayed with Day Glo® pigments dissolved in acetone. This method was time efficient but made the identification of marked flies difficult in the field as well as in trap catches. Recapture of these flies was minimal and thus this method was discontinued after three releases.

Trapping Technique

Modified Stoneville Malaise traps of mesh saran screen fitted with trap tops constructed from Nalgene® polypropylene one liter jars with inverted funnels were used to collect tabanids (Figure 8). One inch strips of rubber tire tube with a metal grommet at each end were used for trap top attachment. Traps were baited with ca. 3.6 kg of dry ice placed in a styrofoam bait bucket with three 2 cm holes in the sides to allow sublimating CO_2 gas to escape from beneath the trap (Figure 8).

Traps were operated daily with the exception of periods of inclement weather. The days of recapture post-release were based on the time traps were baited and trap tops collected. Since the average time of trap top collection was ca. 10 am, day zero was designated from the time marked flies were released until 10 am the following day. Hollander and Wright (1980b) found that *T. abactor* were less active during the morning daylight hours, thus this was probably the period of least dispersal. Although the marked engorged flies were not expected to disperse for at

Figure 8. Modified Stoneville Malaise trap with dry ice in styrofoam bait bucket.

least 72 hr, day zero consisted of ca. 5-11 hr of daylight flight time for this group: 1-5 hr on the day of marking and ca. 4 hr the following morning. Marked nonengorged flies were released at dusk so only ca. 4 hr of daylight flight time were available for this group on day zero from dawn until 10 am the following morning. Day one for both groups was recorded from 10 am the first day post-release until 10 am the second day post-release. Each succeeding day was based on the next 24 hr interval of 10 am to 10 am.

Populations of _T. abactor_ were monitored weekly with two Malaise traps located in the study area from April of each year to determine the peak population periods of this species. The traps were operated during this study for 42 days from 25 June to 18 August in 1982 and for 38 days from 30 June to 7 August in 1983. All tabanids in each collection were counted and identified to species. The number of marked and unmarked _T. abactor_ trapped per trap per day was recorded.

Determination of Survival of Marked Flies

The effect of marking on the survival of _T. abactor_ was determined since a survival factor was needed to calculate population estimates by the method of Harlan and Roberts (1976). Four treatment groups of _T. abactor_ were used to test various aspects of the marking technique: engorged control, engorged marked, nonengorged control and nonengorged marked. Flies were marked and handled using the procedures described previously. Each replication consisted of 50 flies per treatment maintained in 46 cm square screen cages with vertical cloth strips provided as resting sites for the flies (Figure 9). A 10% sucrose solution and water were provided via poultry waterers. The cages were maintained in

Figure 9. Screen cage used to determine the effect of marking on the survival of _T. abactor_.

the field in a shaded area at the release site. Survival counts were made at 12 hr intervals for 96 hr. Three replications were completed from 20 July through 3 August 1984.

CHAPTER IV

RESULTS AND DISCUSSION

Release and Recapture of Marked *Tabanus abactor*

In 1982, a total of 17,353 engorged and nonengorged *T. abactor* was marked and released with 1,222 (7.04%) recaptured (Table I). In 1983, 27,800 flies were marked and released with 1,540 (5.54%) recaptured (Table I). The overall recapture rates achieved in this study were almost two times those reported in other tabanid mark-recapture studies. Thornhill and Hays (1972) achieved recapture rates of 1.0 and 3.5% in Alabama. Sheppard and Wilson (1976) reported recapture rates of 1.5 and 3.1% in Louisiana and Harlan and Roberts (1976) had recapture rates of 1.8 and 4.3% in Mississippi. The recapture rates of the latter two studies were based on an estimated number of flies marked by self-marking traps. The recapture rates in this study and that of Thornhill and Hays (1972) were based on the actual numbers of flies marked. Thus, the results of these two studies were more accurate.

Engorged Flies

In 1982, 8,238 engorged *T. abactor* were marked and released with 756 (9.18%) recaptured. In 1983, 11,583 engorged flies were marked and released with 1,036 (8.94%) recaptured. The recapture rates for the marked engorged flies in both years were similar (Table I). An average of 823.8 and 1053.0 engorged flies were marked per day for 10 days and

TABLE I

NUMBER OF MARKED AND RECAPTURED *TABANUS ABACTOR* IN 1982 AND 1983

STATUS	YEAR		NO. MARKED/RELEASED	NO. RECAPTURED	% RECAPTURED
Engorged	1982		8,238	756	9.18
	1983		11,583	1,036	8.94
		Total	19,821	1,792	9.04
Nonengorged	1982		9,115	466	5.11
	1983		16,217	504	3.11
		Total	25,332	970	3.83
Total	1982		17,353	1,222	7.04
	1983		27,800	1,540	5.54

11 days in 1982 and 1983 respectively. Over 5% of the flies marked on any given day were recaptured with the exception of those marked on the last two days in 1982 (Table II).

Nonengorged Flies

A total of 9,115 nonengorged flies was marked and released in 1982 with 466 (5.11%) recaptured. In 1983, 16,217 nonengorged flies were marked and released with 504 (3.11%) recaptured. The mean nonengorged flies marked per day was 911.5 and 1247.5 for 10 and 13 days in 1982 and 1983 respectively. Although 1.8 times as many marked nonengorged flies were released in 1983 as in 1982, the recapture rate was 2% less (Table I). The recapture rates for nonengorged flies released on any given day were found to be less in 1983 with less than 4% recaptured on eight days (Table III) as compared to less than 4% recaptured on only three days in 1982 (Table II). Two of those low recapture rates in 1982 were of nonengorged flies marked with fluorescent dusts. With one exception, the five lowest recapture rates for individual mark days of nonengorged flies in 1983 occurred for the last five days that specimens were marked (Table III). These low recapture rates may be related to the lower survival of specimens from an older population.

Dispersal Activity of *Tabanus abactor*

Dispersal Time of Engorged Flies

Engorged flies were recaptured in greatest numbers on days three and four post release; 46.36 and 18.41% in 1982 (Figure 10) and 30.89 and 29.83% in 1983 (Figure 11). Only 2.50 and 1.25% of the total marked engorged flies were recaptured on days zero through two in 1982 and

TABLE II

THE NUMBER OF *TABANUS ABACTOR* MARKED PER DAY AND THE NUMBER OF THOSE MARKED FLIES RECAPTURED THROUGHOUT THE STUDY IN 1982

ENGORGED				NONENGORGED			
DATE	NO. MARKED	NO. RECAPTURED	% RECAPTURED	DATE	NO. MARKED	NO. RECAPTURED	% RECAPTURED
6/22	1051	146	13.89	6/25	570	34	5.96
6/23	393	43	10.94	6/26	685*	31	4.53
6/29	1364	182	13.34	7/01	1001*	15	1.50
6/30	684	39	5.70	7/02	1013*	6	0.59
7/13	1244	88	7.07	7/07	1000	106	10.60
7/19	1197	103	8.60	7/08	1052	77	7.32
8/03	975	103	10.56	7/14	1180	85	7.20
8/04	850	43	5.06	7/20	1016	13	1.28
8/09	309	6	1.94	8/05	868	60	6.91
8/10	171	3	1.75	8/06	730	39	5.34
TOTAL	8238	756	9.18		9115	466	5.11

* Fluorescent Dust

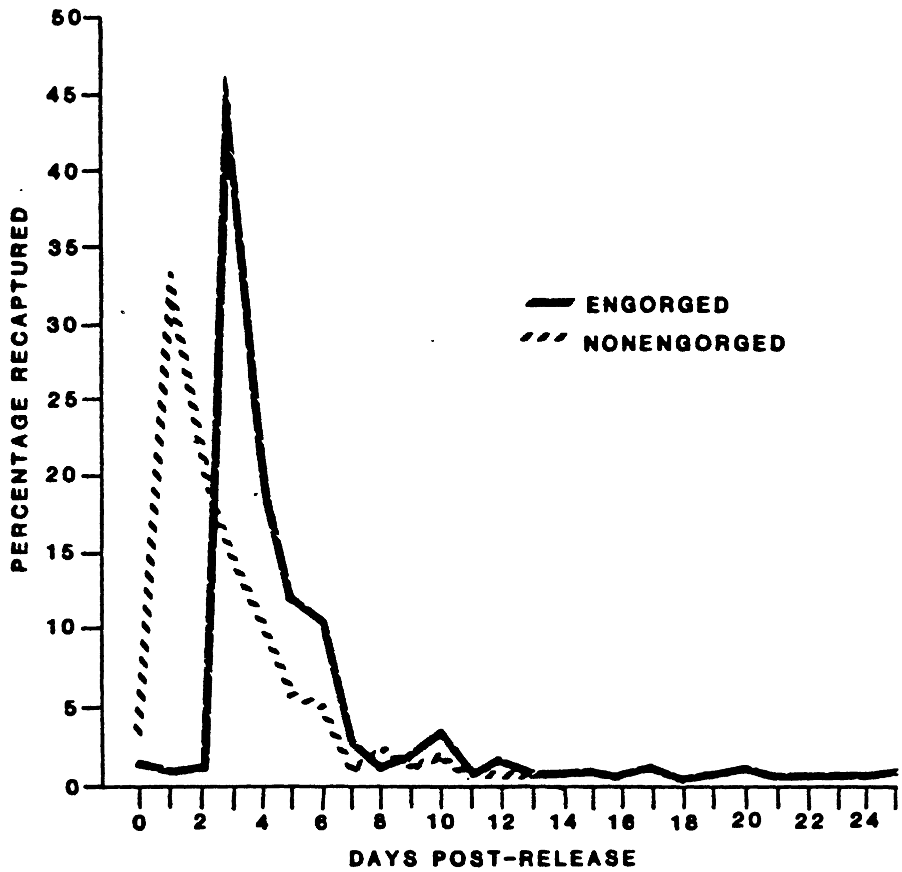
TABLE III

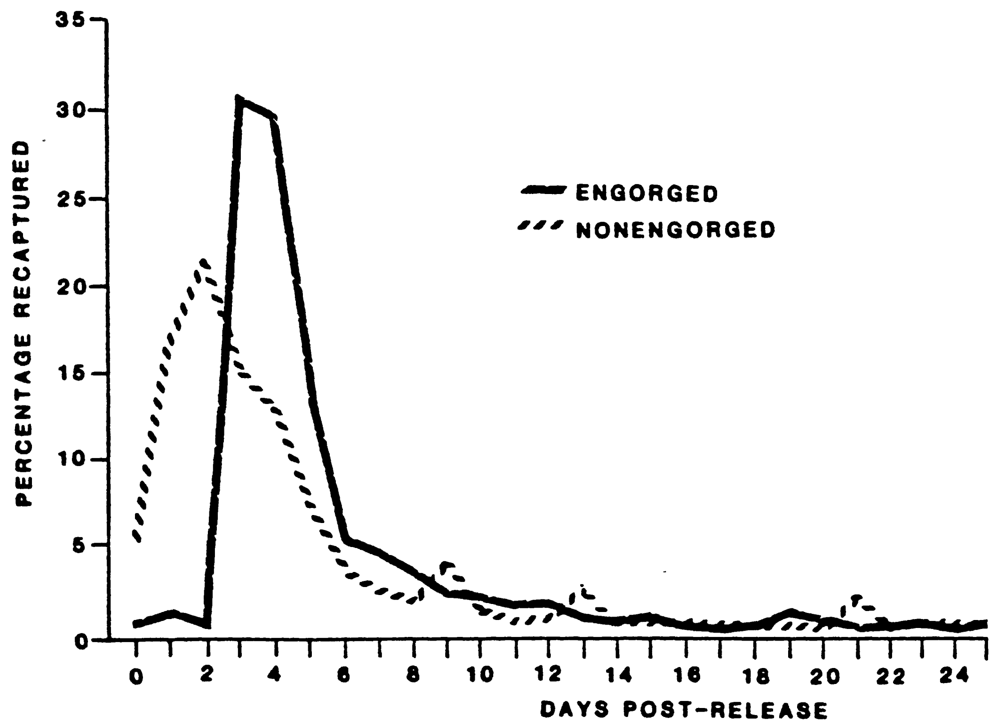
THE NUMBER OF TABANUS ABACTOR MARKED PER DAY AND THE NUMBER OF THOSE MARKED FLIES RECAPTURED THROUGHOUT THE STUDY IN 1983

ENGORGED				NONENGORGED			
DATE	NO. MARKED	NO. RECAPTURED	% RECAPTURED	DATE	NO. MARKED	NO. RECAPTURED	% RECAPTURED
6/27	434	65	14.98	6/30	670	49	7.31
6/28	55	5	9.09	7/01	579	34	5.87
6/29	660	48	7.27	7/02	565	19	3.36
7/05	853	49	5.74	7/07	910	11	1.21
7/06	699	67	9.59	7/08	1191	41	3.44
7/11	1025	63	6.15	7/13	1510	65	4.30
7/12	1247	106	8.50	7/14	868	49	5.65
7/18	1460	186	12.74	7/15	1435	84	5.85
7/19	1785	156	8.87	7/20	1808	38	2.10
7/25	2040	159	7.79	7/21	1185	38	3.21
7/26	1325	132	9.96	7/22	1682	28	1.66
				7/27	1687	40	2.37
				7/28	2127	8	0.38
TOTAL	11,583	1036	8.94		16,217	504	3.11

Figure 10. Percentage recapture of marked, engorged and nonengorged *T. abactor* by days post-release in 1982.

Figure 11. Percentage recapture of marked, engorged and nonengorged *T. abactor* by days post-release in 1983.


PERCENTAGE RECAPTURED
50
45
40
35
30
25
20
15
10
5
0
ENGORGED
NONENGORGED
0 2 4 6 8 10 12 14 16 18 20 22 24
DAYS POST-RELEASE


PERCENTAGE RECAPTURED
35
30
25
20
15
10
5
0
ENGORGED
NONENGORGED
0 2 4 6 8 10 12 14 16 18 20 22 24
DAYS POST-RELEASE

1983 respectively. These flies were assumed to have not taken a complete blood meal at the time of marking. Less than 7 and 12% (Figures 10 and 11) of the total marked engorged flies were recaptured after the eighth day post-release in 1982 and 1983 respectively. This may indicate that a large number of these flies may have emigrated from the trapping area in search of an additional blood meal source or died. In this study, no blood meal sources were available at the release site until ca. five days post-release of engorged flies when cattle were returned to the release site. Less than 1% of the previously marked engorged flies were recaptured on the cattle at this time. However, Wright (unpublished data) found that when cattle were returned daily to a release site, 82% of the total flies recaptured were recaptured at the release site and generally returned to feed at three to four day intervals after engorgement. Since 64.7 and 60.7% of the marked flies were recaptured at least 0.4 km from the release site on days three and four during both years, it is apparent that in the absence of a host, *T. abactor* dispersed from the area where previous blood meals were taken.

Dispersal Time of Nonengorged Flies

Host-seeking activity of the marked nonengorged flies resumed upon release with 3.85 and 5.37% recaptured on day zero in 1982 and 1983. Recapture rates were greatest on days one and two post-release with 33.62 and 21.41% in 1982 and 16.70 and 21.47% in 1983 (Figures 10 and 11). Hollander and Wright (1980) reported that the peak flight activity period for host-seeking *T. abactor* occurred from ca. 12 pm to dusk. Since nonengorged flies were released in the late evening, only ca. 4-5 hr of daylight flight time were available during the collection period of day zero. The data indicated that very few of the nonengorged flies dispersed during the morning hours but that they did disperse during the first peak flight activity period which occurred in the afternoon and was recorded as day one. Thus, the major portion of dispersal of the nonengorged flies occurred on days one and two post-release. Less than 5% of the marked nonengorged flies were recaptured on any given day after day six post-release in both years (Figures 10 and 11) with 5.58 and 16.27% of the total number recaptured after this day for 1982 and 1983 respectively.

Dispersal Distance of Marked Flies

In 1982, 72.76% of all marked engorged and nonengorged flies were recaptured in the eight traps located 0.4 km from the release site and 27.74% were recaptured in the four traps located at 0.8 km (Figure 12). Dispersal of *T. abactor* in 1982 was found to be relatively uniformily distributed. When the trapping area was divided into quadrants containing three traps each (Figure 13), the mean percentages recaptured for the marked flies in the NE, SE, and SW quadrants were found to be 20.29, 17.84 and 23.65 respectively. The mean of the NW quadrant was higher, 38.22%, due to several factors: Trap 7, located in this quadrant, recaptured a larger number of marked flies than any other trap and all three traps in the NW quadrant were placed at the woods' edge, the preferred habitat of this species, in contrast with the other three quadrants having one trap at the woods' edge and two traps in the open field.

In 1983, 58.30% of the recaptured flies occurred in three traps at 0.4 m, 18.05% in three traps at 0.8 km, 12.26% in four traps at 1.2 km, 10.33% in seven traps at 1.6 km and 1.06% in three traps at 2.4 km from

Figure 12. Percentage recapture of *T. abactor* by distance from the release site in 1982 and 1983.

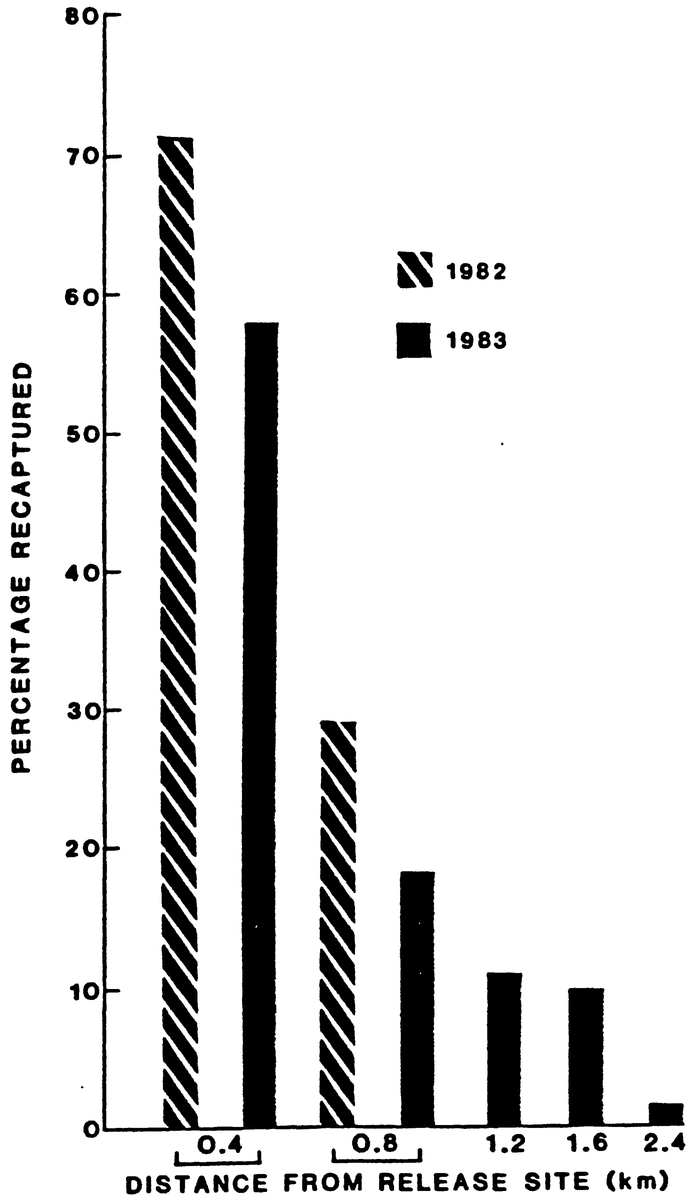
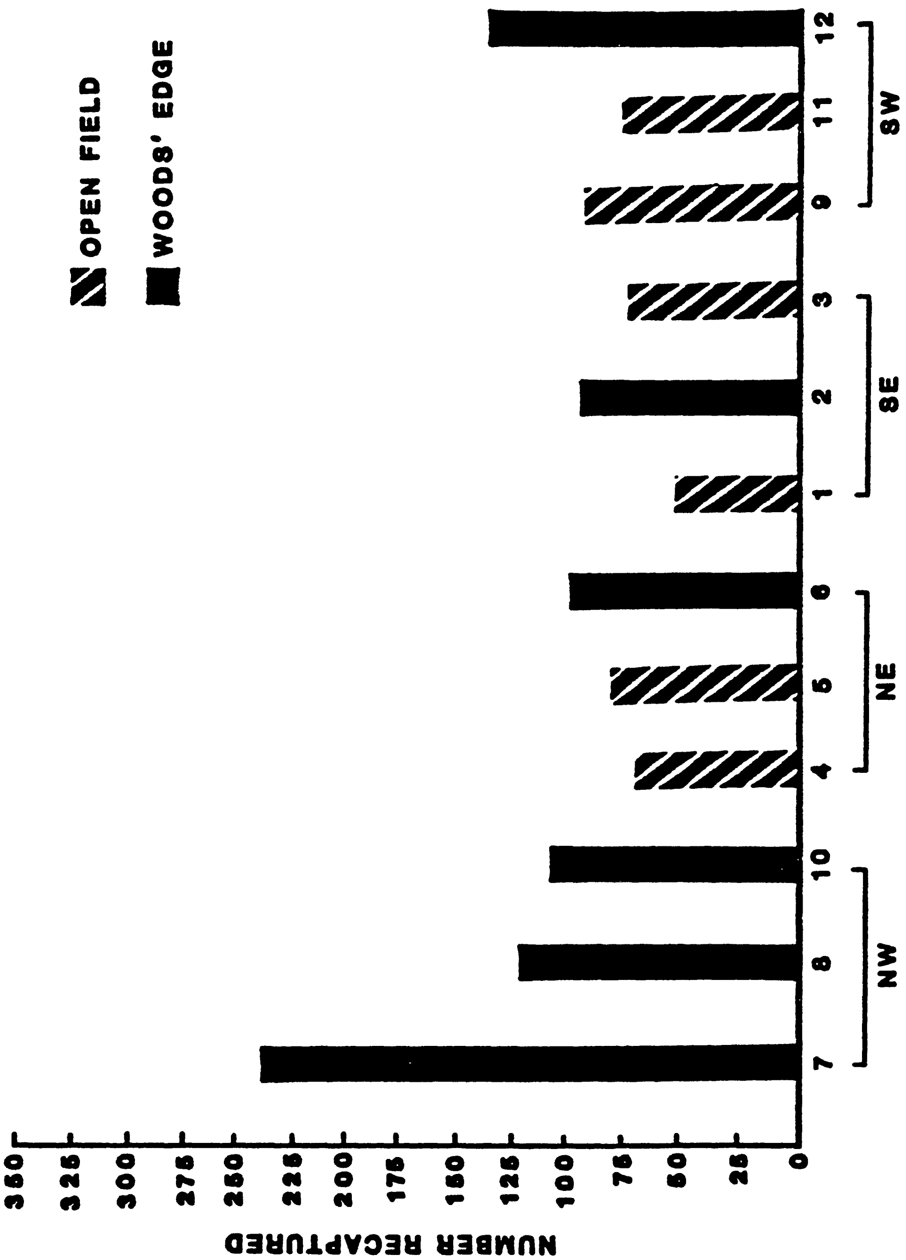

80
70
60
50
40
30
20
10
0
PERCENTAGE RECAPTURED
1982
1983
0.4
0.8
1.2
1.6
2.4
DISTANCE FROM RELEASE SITE (km)

Figure 13. Number of marked _T. abactor_ recaptured per trap per quadrant in 1982.



OPEN FIELD
WOODS' EDGE
NUMBER RECAPTURED
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
7
8
10
4
5
6
1
2
3
9
11
12
NW
NE
SE
SW
TRAP NUMBER BY QUADRANT

the release site (Figure 12). Although the semicircular arrangement of traps in 1983 was designed for measuring dispersal distance and rate, the number of marked flies trapped per trap per distance confirmed the 1982 data that the flies were dispersing in all directions but that the number of recaptured flies was decreasing with distance from the release site (Figure 14). Similar dispersal patterns were observed by other researchers for other tabanid species. Thornhill and Hays (1972) recaptured 70% of their marked flies within 0.8 km of the release site although traps were located up to 1.6 km from the release site. Sheppard and Wilson (1976) recaptured 48% of their marked flies within 0.8 km with a trapping radius of 6.8 km.

Recapture rates for the engorged and nonengorged flies at each distance were similar. In 1982, 74% of the engorged flies and 68% of the nonengorged flies were recaptured at 0.4 km. The remaining 26% engorged and 32% nonengorged flies were recaptured at 0.8 km (Figure 15). In 1983, 58% of the engorged and 57% of the nonengorged flies were recaptured at 0.4 km, 11 and 13% at 1.6 km and 1.5 and 1% at 2.4 km for the engorged and nonengorged flies respectively (Figure 16).

A marked nonengorged T. abactor was recaptured at 2.4 km following a flight period of ca. 4 hr (day zero) indicating a potential dispersal speed of 0.60 km/hr. Although the data indicate that T. abactor has the potential to disperse long distances rapidly, this does not appear to be the usual flight range of this species since a total of 86.89% of the marked flies was recaptured for both years in traps within 0.8 km of the release site. The greater number of traps located at 0.4 km in 1982 may have influenced this high recapture rate but 58.30% of all

Figure 14. Number of marked T. *abactor* recaptured per trap per distance from the release site in 1983.

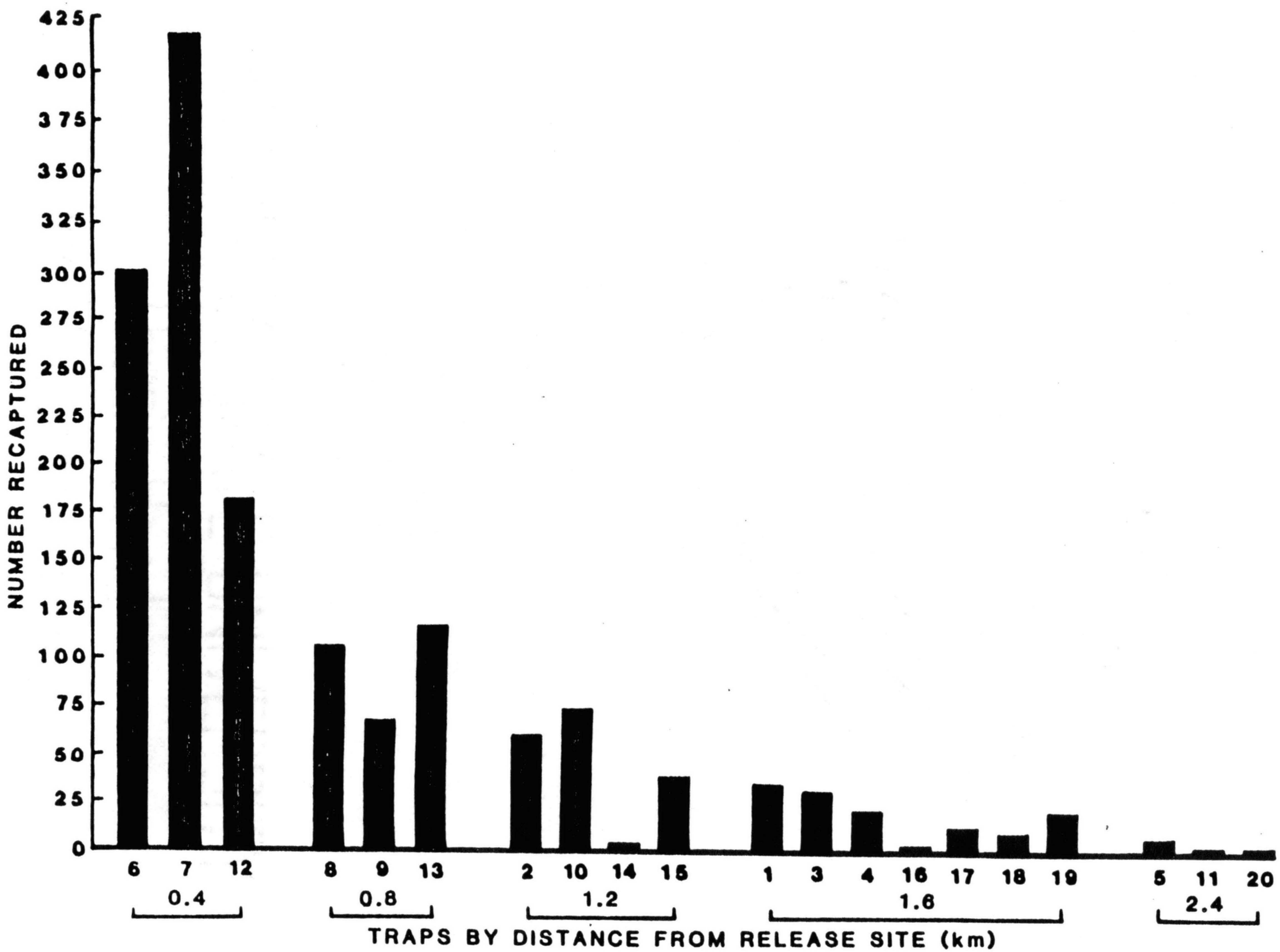

NUMBER RECAPTURED
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
6 7 12
0.4
8 9 13
0.8
2 10 14 15
1.2
1 3 4 16 17 18 19
1.6
5 11 20
2.4
TRAPS BY DISTANCE FROM RELEASE SITE (km)

Figure 15. Percentage of marked, engorged and nonengorged *T. abactor* recaptured by distance from the release site in 1982.

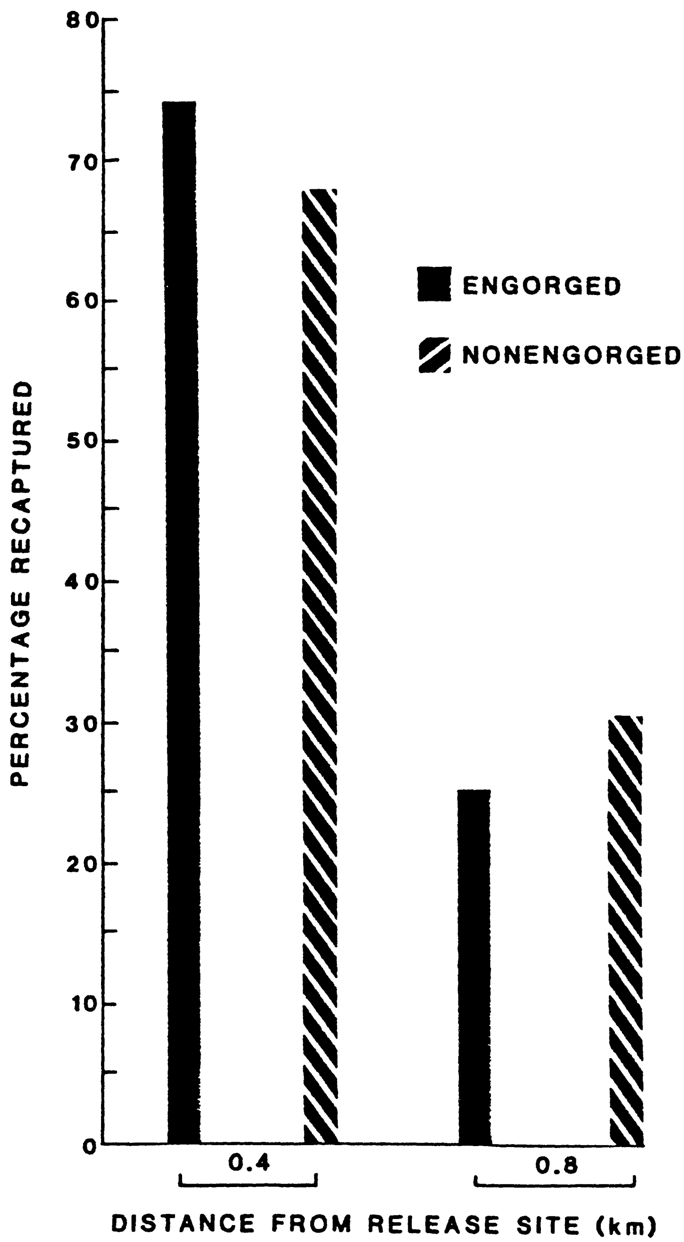
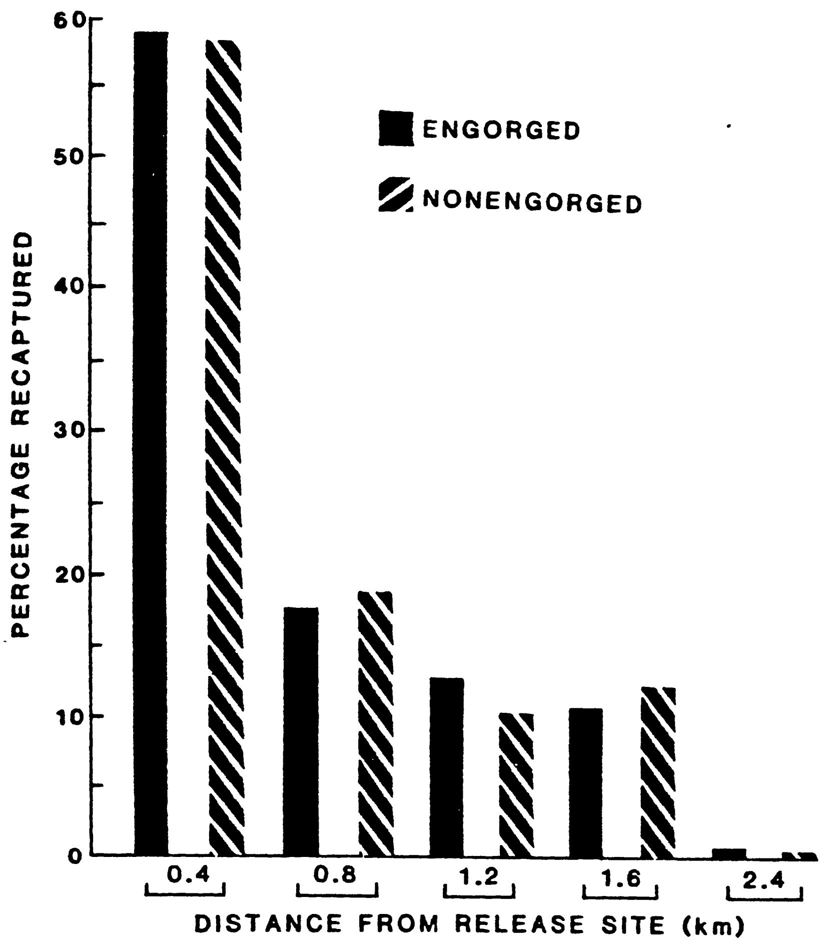

80
70
60
50
40
30
20
10
0
PERCENTAGE RECAPTURED
ENGORGED
NONENGORGED
0.4
0.8
DISTANCE FROM RELEASE SITE (km)

Figure 16. Percentage of marked, engorged and nonengorged *T. abactor* recaptured by distance from the release site in 1983.



60
50
40
30
20
10
0
PERCENTAGE RECAPTURED
ENGORGED
NONENGORGED
0.4
0.8
1.2
1.6
2.4
DISTANCE FROM RELEASE SITE (km)

marked flies trapped in 1983 were in three traps at 0.4 km as compared with 41.70% of the recaptured flies in 17 traps located beyond 0.4 km.

The 1983 data indicate that most marked T. abactor remained within 0.8 km of the release site and did not disperse uniformly beyond this distance. Initially, it was assumed that T. abactor uniformly dispersed from the release site. In order to test this null hypothesis, it was necessary to establish a method for comparing the number of marked flies recaptured in the traps located a specific distance from the release site with the number of flies expected to be recaptured at that distance if dispersal had been uniform. It was assumed that each trap located at a specific distance from the release site would recapture the same number of flies if uniform dispersal occurred. The trapping capacity could then be measured as the number of traps/km of the circumference of a circle at each trapping distance. This ratio-proportion formula of traps/km then theoretically quantified the trapping capacity at each distance. Since different numbers of traps were operated at each distance, a correction factor for trapping capacity at each distance was calculated. This was done by dividing the number of traps/km at a given distance by the total trapping capacity for all distances (Table IV). The expected number of flies recaptured at each trapping distance was calculated by multiplying the correction factor for each trapping distance by the total number of marked flies recaptured in that year (Table IV). The expected number of flies generally decreased with increasing trapping distance with the exception of the expected value calculated for 1.6 km (Table V) at which distance the greatest number of traps were placed. A chi-square test of the observed and expected numbers of flies recaptured in 1983 showed a significant difference indicating

TABLE IV

COMPARISON OF THE EXPECTED RECAPTURE RATE AND OBSERVED RECAPTURE RATE OF *TABANUS ABACTOR* IN 20 TRAPS LOCATED 0.4, 0.8, 1.2, 1.6, AND 2.4 KM FROM THE RELEASE SITE IN 1983

Distance From Release Site (KM)	No. Traps	Circumference (KM)	Trapping Capacity= No. Traps / KM (Circum.)	Correction Factor= Trap. Cap. / Tot. Traps/KM 1/	Expected* Recapture= C.F.(1540) 2/	Observed* Recapture
0.40	3	2.50	1.20	0.372	572	898
0.80	3	5.00	0.60	0.186	286	278
1.20	4	7.50	0.53	0.164	253	189
1.60	7	10.00	0.70	0.217	334	159
2.40	3	15.00	0.20	0.062	95	16
Total	20		3.23		1540	1540

1/ Total traps/KM = 3.23 from column four.

2/ Total number of marked individuals recaptured.

*Significant at $P < 0.0001$, based on 4 df, $\chi^2 = 359.59$.

rejection of the null hypothesis. Thus dispersal of *T. abactor* generally was within 0.4 - 0.8 km and dispersion beyond these distances was not common.

In 1982, a marked engorged fly was recaptured 27 days post-release at 0.4 km while a marked nonengorged fly was recaptured 14 days post-release at this same distance. In 1983, a marked engorged and non-engorged fly were recaptured 23 days post-release at 0.4 km. Although the marked flies may have been moving in and out of the 0.4 km trapping radius, they had a tendency to stay within the trapping area for long periods of time.

Summary of Dispersal Activity

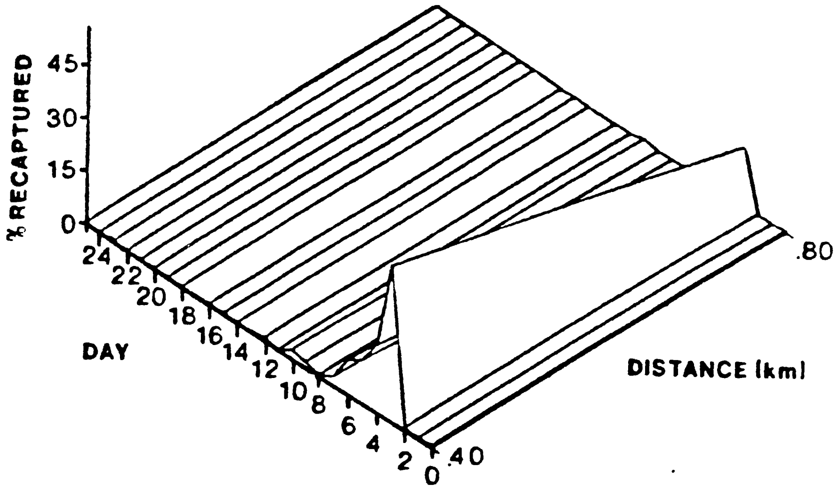
A summary of the relationship of recapture rate to distance from the release site is shown in the three-dimensional Figures 17-20. Recapture of engorged flies was greatest on days three and four post-release at 0.4 km in 1982 and 1983. Recapture of engorged flies decreased with increasing distance and time (Figures 17 and 18). Nonengorged flies were recaptured on days one and two post-release with most flies recaptured at 0.4 - 0.8 km. As observed with the engorged flies, the recapture rate of the nonengorged flies also decreased with increasing distance and time (Figures 19 and 20).

Habitat Comparison

In 1982, six traps located at the woods' edge habitat recaptured 794 (64.98%) of the total marked flies recaptured while the six traps located in the open field habitat recaptured 428 (35.02%) of the total flies (Figure 21). The woods' edge habitat traps collected 59.86% of

Figure 17. Percentage recapture of marked engorged *T. abactor* vs day post-release and distance from the release site in 1982.

Figure 18. Percentage recapture of marked engorged *T. abactor* vs day post-release and distance from the release site in 1983.


% RECAPTURED
45
30
15
0
24
22
20
18
16
14
12
10
8
6
4
2
0
DAY
.40
.80
DISTANCE (km)

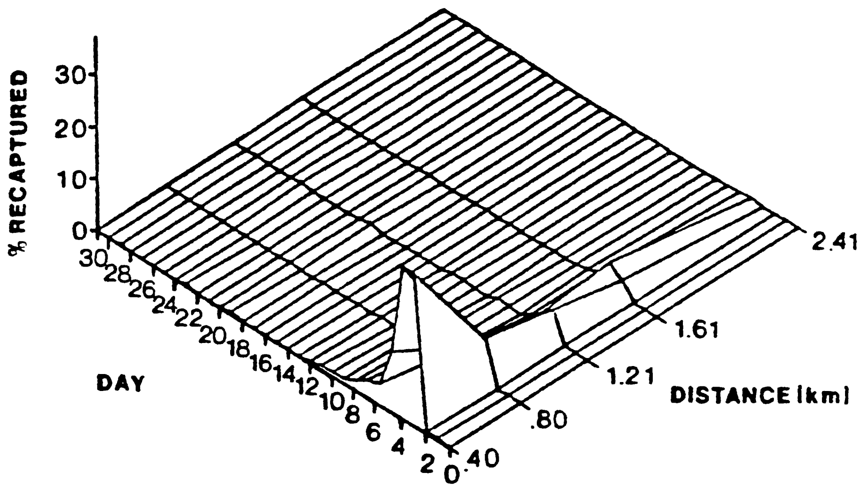
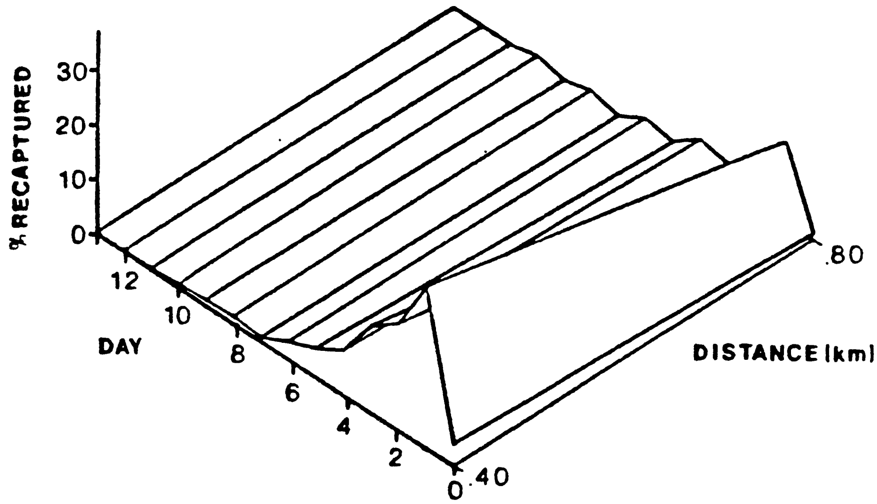

% RECAPTURED
30
20
10
0
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
DAY
.40
.80
1.21
1.61
2.41
DISTANCE (km)

Figure 19. Percentage recapture of marked nonengorged _T. abactor_ vs day post-release and distance from the release site in 1982.

Figure 20. Percentage recapture of marked nonengorged _T. abactor_ vs day post-release and distance from the release site in 1983.


% RECAPTURED
30
20
10
0
12
10
8
6
4
2
0
DAY
.40
.80
DISTANCE (km)

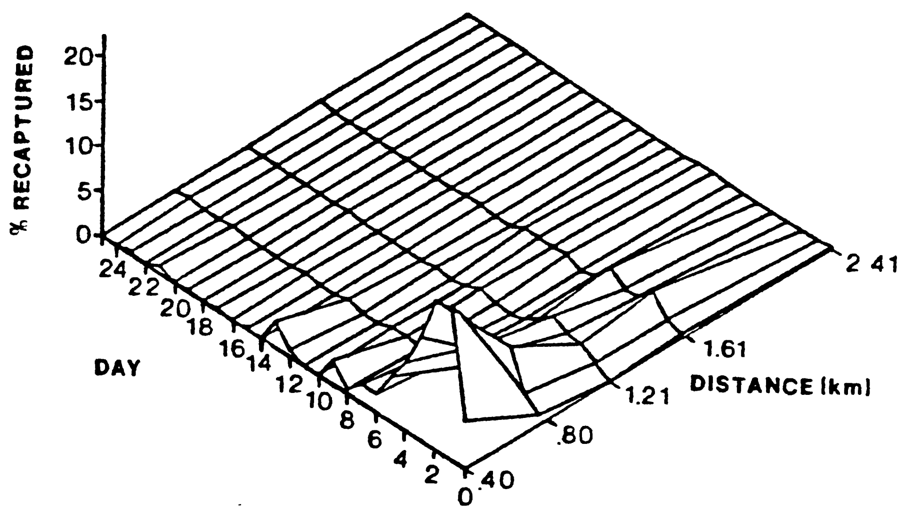
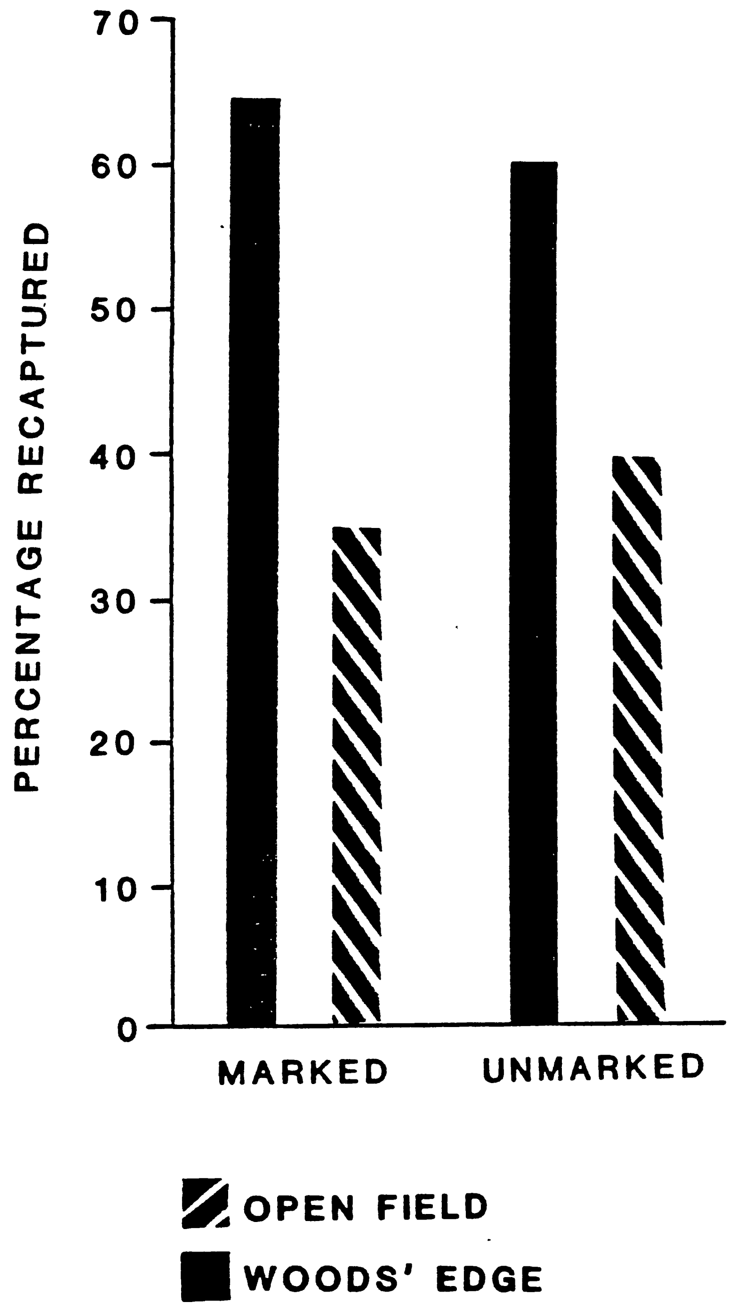

% RECAPTURED
20
15
10
5
0
24
22
20
18
16
14
12
10
8
6
4
2
0
DAY
.40
.80
1.21
1.61
2 41
DISTANCE (km)

Figure 21. Comparison of the percentage of marked and unmarked *T. abactor* captured in the woods' edge and open field habitats in 1982.



70
60
50
40
30
20
10
0
PERCENTAGE RECAPTURED
MARKED
UNMARKED
OPEN FIELD
WOODS' EDGE

the total unmarked flies with the open field habitat traps collecting 40.1% (Figure 21). The two habitats were found to differ significantly (t - test, $P < 0.01$) for both the number of marked flies recaptured and unmarked flies trapped.

Population Estimates of *Tabanus abactor*

Population estimates of host-seeking *T. abactor* were calculated utilizing a formula derived by Harlan and Roberts (1976) to estimate tabanid populations in Mississippi. The formula used to estimate populations was:

$$\text{Population Estimate} = \frac{(\text{No. Marked+No. Trapped})(\text{No. Est. Marked Surviving})}{(\text{No. Recaptured})}.$$

Since this formula is a modified Lincoln Index, the same assumptions outlined for the Index must be met. The assumptions made for this study were as follows:

1. Since marking was determined to increase natural mortality, a survival factor of 0.85 was used to estimate daily survival of marked flies.
2. Marked flies mixed completely with the unmarked population.
3. Catchability was equal for the marked and unmarked populations.
4. Sampling was at discrete 24 hr intervals.
5. Immigration and emigration were equal.
6. Eclosion rate and death rate were equal.

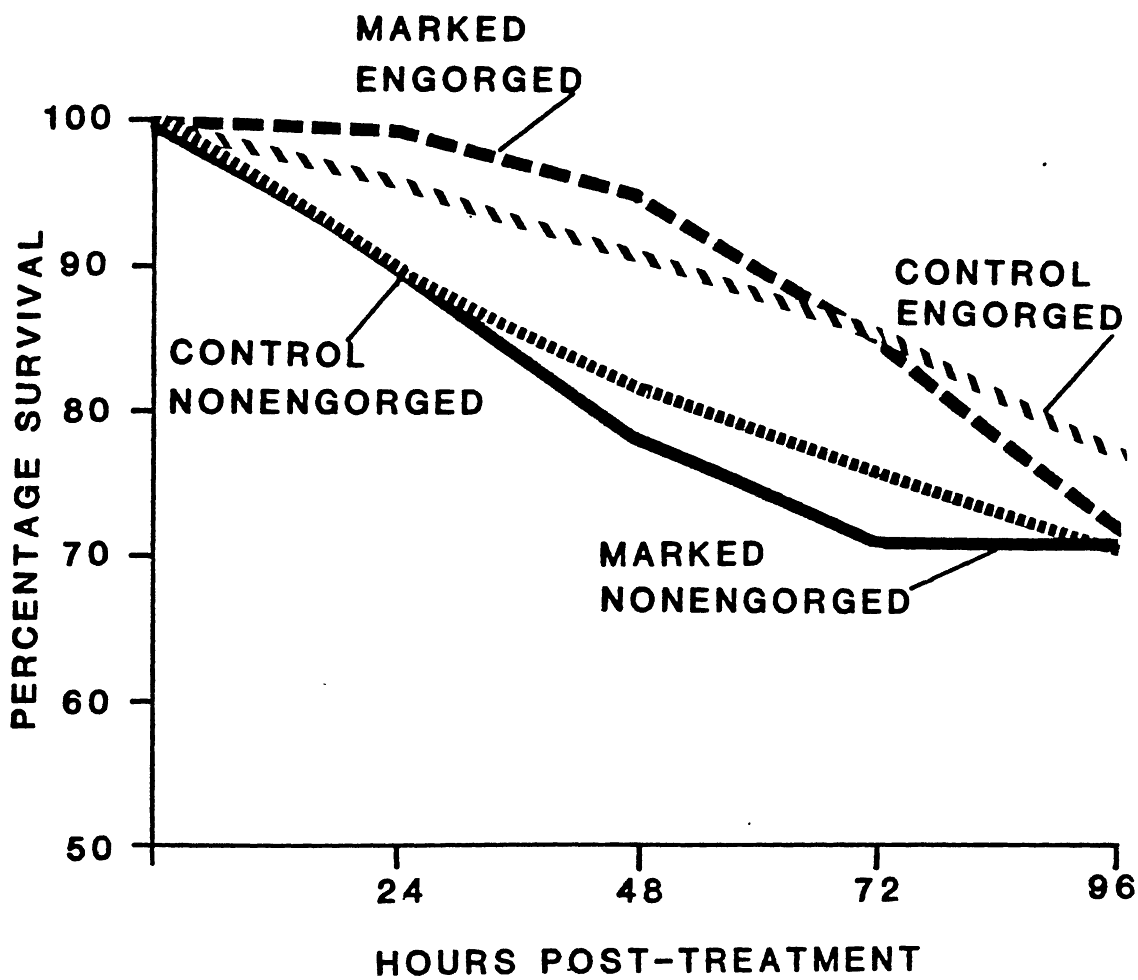
Determination of Survival of Marked Flies

Since the effectiveness of a study to estimate populations by a mark-recapture technique depends upon the survivability of the marked subjects, the methods used in marking both engorged and nonengorged flies were evaluated to determine the survival rate of the marked flies. These data were then used to calculate a daily survival factor for marked flies which was incorporated into the index used for estimating the daily T. abactor populations.

Survival of marked flies decreased with time for all treatments (Figure 22). Engorged flies, control and marked treatment groups, exhibited a steady decrease in survival by ca. 5-7% with each 24 hr interval. Mortality of these flies was greatest from 72-96 hr. At the end of 96 hr, survival of the engorged, control and marked flies was 78.9 and 73.4% respectively (Figure 22). Nonengorged, control and marked treatment groups exhibited greatest mortality during the first 48 hr, decreasing less rapidly over the next 24 hr intervals (Figure 22). At the end of 96 hr, survival of the nonengorged, control and marked flies was 71.0 and 72.0% respectively. The decreased survival of the nonengorged, control and marked treatment groups at 24-48 hr post-treatment was attributed to excessive activity of the flies in attempts to escape from the cages. These two groups of flies experienced greater physical damage to the wings and body from flying into the cage walls during this period than did the engorged flies which were in a state of reduced activity while digesting the blood meal. The engorged flies increased activity in the cages at ca. 72 hr post-treatment. It is thought that survival of the marked nonengorged flies after release was greater than the cage study results indicated during the first 48 hr.

Although analysis of variance procedures (ANOVA, $P < 0.0001$) indicated a significant difference for survival of the treatment groups with time, no significant difference was observed between the treatment groups at 96 hr post-treatment (t-test, $P > 0.10$). Thus the average daily survival factor was calculated from the survival data at 96 hr since the factors influencing reduced survival of the nonengorged flies during the first 48 hr were at least in part due to the cage environment.

Figure 22. Percentage survival of control and marked, engorged and nonengorged *T. abactor* held in screen cages in the field vs hours post-treatment.


MARKED
ENGORGED
100
90
80
70
60
50
PERCENTAGE SURVIVAL
CONTROL
ENGORGED
CONTROL
NONENGORGED
MARKED
NONENGORGED
24
48
72
96
HOURS POST-TREATMENT

The daily survival factor was calculated as follows: (1) an average of the percent survival of the marked engorged (.734) and marked nonengorged (0.720) flies at 96 hr (4 days) was determined (0.727); (2) this finite rate was then converted to an instantaneous rate ($\ln(0.727) = -0.319$) which was divided by 4 days to determine the instantaneous rate of survival per day ($-0.319/4 = -0.080$); (3) the instantaneous rate was then reconverted to the finite rate ($e^{-0.080} = 0.923$) of survival per day of marked flies remaining in the population. However, this daily survival rate of 0.923 was based on the survival of marked flies maintained in a protected environment and did not take into consideration any additional mortality due to predation or environmental elements. Although the exact extent of increased mortality caused by any of these factors could not be determined, it was assumed that they could decrease survival by at least an additional 7.7% in a natural situation. Therefore, a survival factor of 0.85 was used to calculate daily population estimates.

Population Estimates

Four parameters were used to calculate separate daily population estimates for the engorged and nonengorged fly groups in 1982 and 1983: the number of (1) flies marked, (2) unmarked flies trapped, (3) estimated marked flies surviving in the population and (4) marked flies recaptured. Parameters one, two and three were directly related to the trends of the population estimates and had less influence on the day to day fluctuation of the population estimates than parameter four which was inversely related to the estimates; small daily recapture rates resulted in larger population estimates while large recapture rates resulted in smaller population estimates. Since the number of marked engorged flies recaptured was greater than the marked nonengorged flies, a weighted mean was used to calculate the average daily population estimates. Weight was placed on the number of flies recaptured to minimize the effects of the varying recapture rates:

$$\text{Daily popn. est.} = \frac{\begin{pmatrix}\text{No. Engorged}\\ \text{Recaptured}\end{pmatrix}\begin{pmatrix}\text{Engorged}\\ \text{Popn. Est.}\end{pmatrix} + \begin{pmatrix}\text{No. Nonengorged}\\ \text{Recaptured}\end{pmatrix}\begin{pmatrix}\text{Nonengorged}\\ \text{Popn. Est.}\end{pmatrix}}{\begin{pmatrix}\text{No. Engorged + Nonengorged}\\ \text{Recaptured}\end{pmatrix}}$$

In 1982, population estimates were calculated individually for 31 days during the period of 26 June to 27 July for an area of 2.1 km^2 (210 hectares) as sampled by 12 traps (Table V). The daily population estimates of host-seeking flies fluctuated greatly ranging from a low of 22,767 flies during early season to a high of 2,686,613 flies during mid-season (Figure 23). The daily mean estimated population was 529,047 flies with an estimated 2,519 flies per hectare per day.

In 1983, population estimates were calculated individually for 38 days during the period of 1 July to 7 August for an area of 4.6 km^2 (460 hectares) as sampled by 17 traps (Table VI). The daily population estimates of host-seeking flies ranged from a low of 66,960 flies during early season to a high of 2,794,389 flies during mid-season (Figure 24). The estimated daily population was 845,003 flies with an estimated 1,837 flies per hectare per day. The standard deviations of the population estimates indicated that the estimates fluctuated greatly from day to day during each year (Tables V and VI).

A comparison of 1982 and 1983 daily population estimates is shown in Figure 25. Seasonal trends were observed to be similar with the exception of an increase in the population during late July in 1983 as compared with a decrease in the population at this time in 1982.

TABLE V

ESTIMATION PARAMETERS AND THE POPULATION ESTIMATES OF TABANUS ABACTOR IN 1982

DATE	NO. TRAPPED	ENGORGED NO. MARKED				NONENGORGED NO. MARKED				WEIGHTED POPULATION EST.
		NO. MARKED	NO. RECAPTURED	EST. SURVIVAL(.85)	EST. POPULATION	NO. MARKED	NO. RECAPTURED	EST. SURVIVAL(.85)	EST. POPULATION	
6/22	—	1051	—	1051	—	—	—	—	—	—
6/23	—	393	—	1286	—	—	—	—	—	—
6/24	—	—	—	1093	—	—	—	—	—	—
6/25	399	—	—	929	—	570	2	570	—	—
6/26	1006	—	23	790	35,344	685	10	1168	198,677	684,839
6/27	1037	—	58	652	12,309	—	19	984	54,690	22,767
6/28	1572	—	63	505	13,106	—	18	820	72,433	26,290
6/29	1392	1364	13	1740	370,620	—	7	682	136,303	288,609
6/30	1793	684	4	2152	1,334,778	—	4	574	257,870	796,324
7/1	1263	—	2	1826	1,154,945	1001	2	1485	1,682,505	1,418,725
7/2	2718	—	145	1550	30,604	1031	13	2292	663,270	82,659
7/3	1952	—	65	1194	37,051	—	3	1937	1,262,278	91,105
7/4	1245	—	10	960	120,480	—	2	1644	1,025,034	271,239
7/5	1007	—	7	807	116,900	—	1	1396	1,407,168	278,184
7/6	1322	—	5	680	180,472	—	1	1185	1,567,755	411,686
7/7	1168	—	3	574	224,051	1000	2	2007	2,177,595	1,005,469
7/8	3637	—	2	485	882,458	1052	39	2756	334,112	360,861

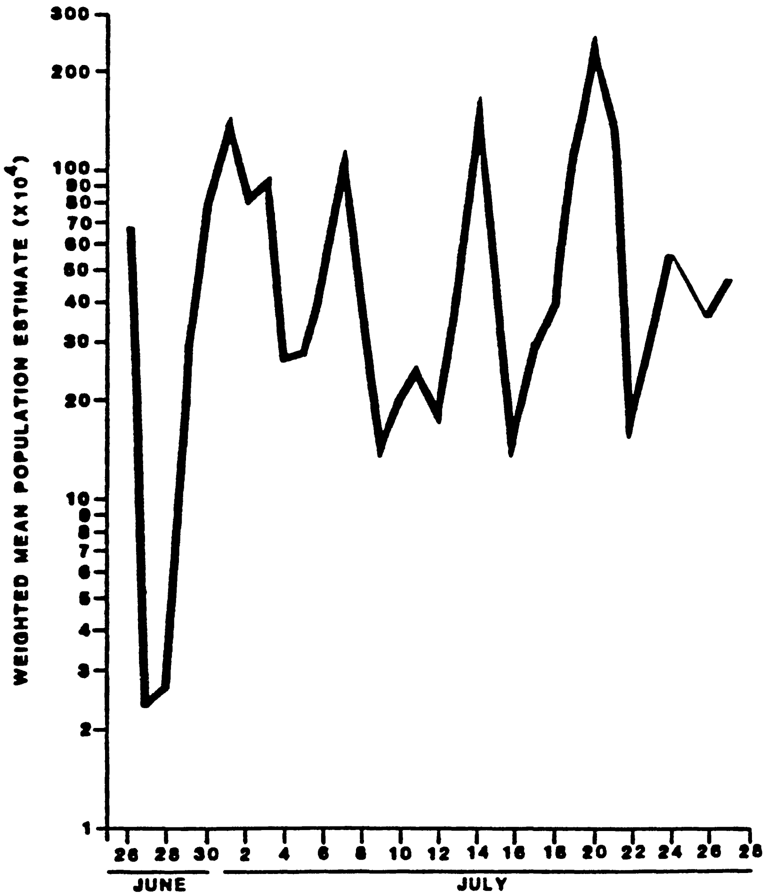
TABLE V (Continued)

DATE	NO. TRAPPED	ENGORGED NO. MARKED	ENGORGED NO. RECAPTURED	ENGORGED EST. SURVIVAL(.85)	ENGORGED EST. POPULATION	NONENGORGED NO. MARKED	NONENGORGED NO. RECAPTURED	NONENGORGED EST. SURVIVAL(.85)	NONENGORGED EST. POPULATION	WEIGHTED POPULATION EST.
7/9	2824	--	5	411	232,544	--	51	2309	130,164	139,305
7/10	1840	--	1	345	635,145	--	20	1920	178,560	200,302
7/11	3996	--	1	292	1,167,124	--	30	1615	216,733	247,391
7/12	1525	--	1	248	378,448	--	12	1347	172,528	188,368
7/13	4445	1224	0	1434	--	--	12	1135	421,558	421,558
7/14	5907	--	6	1219	1,201,325	1180	9	2135	1,683,329	1,490,527
7/15	4530	--	0	1031	--	--	17	1807	483,319	483,319
7/16	4964	--	59	876	74,579	--	23	1521	329,792	146,163
7/7	6589	--	14	695	327,792	--	29	1274	290,736	302,801
7/8	4134	--	1	578	2,390,030	--	16	1058	274,419	398,867
7/19	3996	1197	7	1688	1,253,943	--	3	886	1,181,038	1,232,072
7/20	7002	--	6	1429	1,669,072	1016	3	1766	4,721,695	2,686,613
7/21	3742	--	0	1209	--	--	4	1499	1,403,814	1,403,814
7/22	4120	--	54	1028	79,461	--	6	1270	873,337	158,849
7/23	3860	--	21	828	153,022	--	3	1075	1,384,242	306,925
7/24	4014	--	9	686	306,642	--	2	911	1,829,288	583,487
7/25	--	--	--	575	--	--	--	773	--	--

TABLE V (Continued)

DATE	NO. TRAPPED	ENGORGED NO. MARKED	NO. RECAPTURED	EST. SURVIVAL(.85)	EST. POPULATION	NONENGORGED NO. MARKED	NO. RECAPTURED	EST. SURVIVAL(.85)	EST. POPULATION	WEIGHTED POPULATION EST.
7/26	3656	--	9	489	199,132	--	2	657	1,201,653	381,409
7/27	2536	--	3	408	345,304	--	2	557	706,833	489,916
N	32	6	31	36	28	8	32	33	31	31
MEAN	2975	989	19	937	533,096	942	11	1364	913,636	529,047
STD. DEV.	1752	374	31	473	610,441	205	12	568	943,931	581,724

Figure 23. Daily population estimates of *T. abactor* as calculated by a weighted mean of engorged and nonengorged population estimates in 1982.



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WEIGHTED MEAN POPULATION ESTIMATE (X10^4)
26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26 28
JUNE
JULY

TABLE VI

ESTIMATION PARAMETERS AND THE POPULATION
ESTIMATES OF TABANUS ABACTOR IN 1983

DATE	NO. TRAPPED	ENGORGED NO. MARKED	NO. RECAPTURED	EST. SURVIVAL(.85)	EST. POPULATION	NONENGORGED NO. MARKED	NO. RECAPTURED	EST. SURVIVAL(.85)	EST. POPULATION	WEIGHTED POPULATION EST.
6/27	—	434	—	434	—	—	—	—		
6/28	—	55	—	424	—	—	—	—		
6/29	—	660	—	1020	—	—	—	—		
6/30	1048	—	1	867	—	670	1	670	—	—
7/1	1128	—	13	736	64,598	579	13	1148	151,889	108,244
7/2	1073	—	26	615	25,996	565	22	1529	115,370	66,960
7/3	1080	—	16	501	34,319	—	10	1281	139,629	74,823
7/4	995	—	6	412	68,735	—	11	1081	98,862	88,229
7/5	—	853	—	1198	—	—	—	909	—	—
7/6	1340	699	7	1717	501,855	—	2	773	518,683	505,595
7/7	1525	—	2	1454	1,110,129	910	5	1565	763,720	862,694
7/8	1446	—	2	1234	893,416	1191	5	2517	1,329,985	1,205,251
7/9	1485	—	19	1047	82,878	—	13	2135	246,018	149,154
7/10	2980	—	47	874	56,289	—	16	1804	337,799	127,784
7/11	3528	1025	23	1728	343,797	—	15	1520	359,024	349,808
7/12	3508	1247	8	2696	1,605,131	—	3	1279	1,496,856	1,575,602
7/13	3163	—	15	2285	484,115	1510	10	2595	1,215,239	776,565

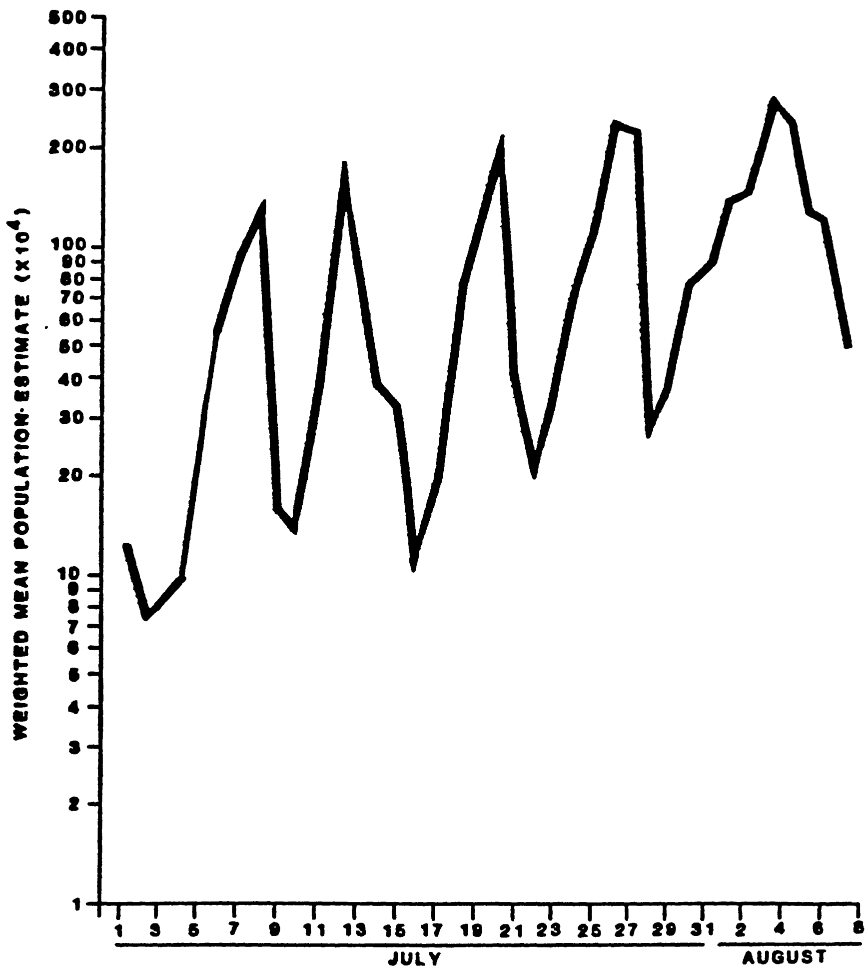
TABLE VI (Continued)

DATE	NO. TRAPPED	ENGORGED NO. MARKED	ENGORGED NO. RECAPTURED	ENGORGED EST. SURVIVAL(.85)	ENGORGED EST. POPULATION	NONENGORGED NO. MARKED	NONENGORGED NO. RECAPTURED	NONENGORGED EST. SURVIVAL(.85)	NONENGORGED EST. POPULATION	WEIGHTED POPULATION EST.
7/14	1357	--	12	1929	220,067	868	15	3065	457,707	352,356
7/15	1732	--	32	1630	89,854	1435	18	4027	712,555	314,026
7/16	2451	--	69	1358	49,597	--	38	3408	223,224	111,259
7/17	4660	--	46	1096	112,126	--	52	2865	259,613	190,384
7/18	5420	1460	16	2352	1,013,712	--	24	2391	542,358	730,900
7/19	5549	1785	11	3771	2,518,000	--	23	2012	487,429	1,144,378
7/20	5218	--	9	3196	1,856,166	1808	13	3498	1,894,033	1,878,542
7/21	6326	--	99	2709	175,811	1185	20	4148	1,561,929	408,772
7/22	3212	--	130	2218	57,020	1682	28	5191	912,504	208,625
7/23	4677	--	66	1775	127,558	--	25	4389	825,483	319,296
7/24	6005	--	18	1452	485,855	--	25	3709	894,611	723,504
7/25	5078	2040	17	3260	1,368,241	--	19	3131	839,932	1,089,411
7/26	6488	1325	13	4082	2,457,364	--	8	2646	2,148,552	2,339,721
7/27	5275	--	3	3458	6,083,775	--	10	2242q	1,184,897	2,315,407
7/28	4736	--	69	2937	204,526	--	10	1897	900,316	292,601
7/29	8149	--	124	2438	162,658	1687	15	3291	2,161,309	378,340
7/30	3484	--	44	1967	157,718	2127	7	4912	3,942,231	677,161

TABLE VI (Continued)

DATE	NO. TRAPPED	ENGORGED				NONENGORGED				WEIGHTED POPULATION EST.
		NO. MARKED	NO. RECAPTURED	EST. SURVIVAL(.85)	EST. POPULATION	NO. MARKED	NO. RECAPTURED	EST. SURVIVAL(.85)	EST. POPULATION	
7/31	4080	—	17	1634	393,794	—	10	4169	1,705,121	879,471
8/1	4393	—	13	1374	465,680	—	3	3535	5,179,953	1,349,606
8/2	7539	—	18	1157	485,747	—	3	3002	7,547,028	1,494,501
8/3	7943	—	9	968	854,959	—	1	2549	20,249,256	2,794,389
8/4	3156	—	2	815	1,286,885	—	2	2166	3,420,114	2,353,500
8/5	3099	—	5	691	428,973	—	1	1840	5,704,000	1,308,144
8/6	2097	—	1	583	1,223,134	—	0	1563	—	1,223,134
8/7	2005	—	2	495	496,733	—	0	1328	—	496,733
N	38	11	38	42	37	13	38	38	35	37
MEAN	3642	861	26	1633	755,871	1248	13	2507	2,012,207	845,003
STD. DEV.	2095	767	33	988	1,120,440	507	11	1182	3,611,233	747,776

Figure 24. Daily population estimates of *T. abactor* as calculated by a weighted mean of engorged and nonengorged population estimates in 1983.


WEIGHTED MEAN POPULATION ESTIMATE (X10⁴)
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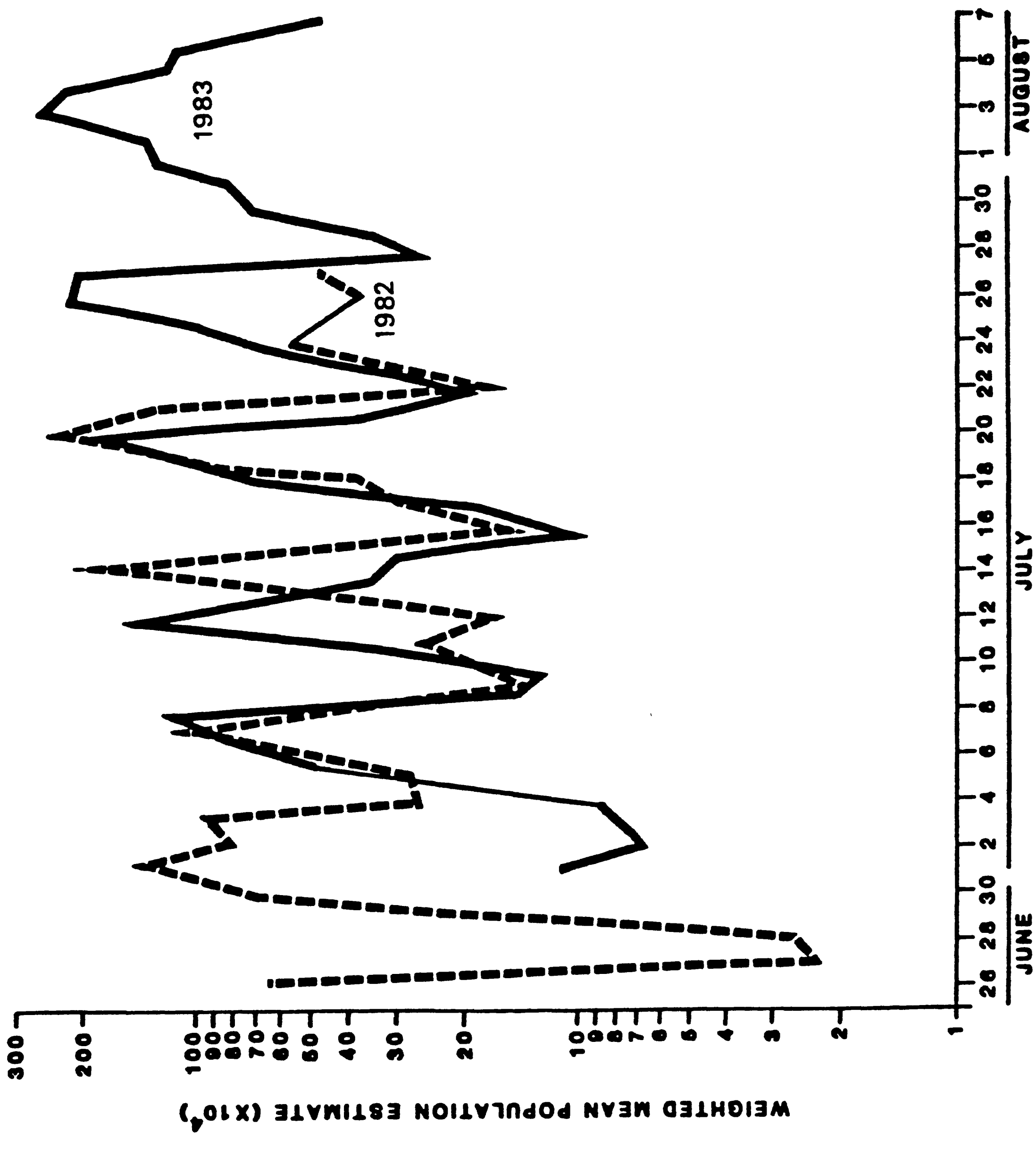
JULY
AUGUST

Figure 25. Comparison of the seasonal trends of population estimates of *T. abactor* in 1982 and 1983.


WEIGHTED MEAN POPULATION ESTIMATE (X10^4)
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JULY
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AUGUST
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1982
1983

Less than 100 male _T. abactor_ were trapped or observed during this study and were not counted in any of the trap totals used for estimating populations. However, assuming a 1:1 male to female ratio, the population estimates for 1982 and 1983 would have been 1,058,094 (2.1 km^2) and 1,690,006 (4.6 km^2) _T. abactor_ respectively.

Population estimates were also calculated using the actual survival factor of 0.92 which was obtained from the results of the cage study. Mean daily population estimates of 899,380 (4,283/hectare) and 1,436,505 (3,123/hectare) _T. abactor_ were calculated for 1982 and 1983 respectively. These estimates were over 1.5 times greater than the estimates calculated with the survival factor of 0.85. Although it is assumed that the population estimates calculated with the 0.92 survival factor are too high, this assumption can not be qualified. However, field and laboratory observations based on host-seeking and feeding behavior can be stated to justify usage of the lower survival factor. Firstly, the total tabanid population of a given area is comprised of subpopulations feeding at regular 3-4 day intervals. Since only the host-seeking population on a given day was estimated, the total _T. abactor_ population would be greater than the estimated population. Secondly, if the per hectare estimates are compared with the mean number of flies marked per day, 868 in 1982 and 1,158 in 1983; assuming that most host-seeking flies within one hectare of the mark-release site were attracted to the tethered cattle and marked on any given day, then the estimates based on the 0.85 survival factor were more reasonable.

Harlan and Roberts (1976) estimated mean tabanid populations of 989,195 and 275,497 for two, 23 day periods in 1974 for a 4.0 mi^2 (10.4 km^2) area. They indicated that the estimated population for the second part of the study was the more accurate since the number of flies marked during the first part of the study may have been overestimated. In the present study, the mean population of *T. abactor* was estimated to be: 529,047 and 845,007 for areas of 2.1 and 4.6 km^2. It is difficult to compare these two studies since they estimated populations of different tabanid species of dissimilar geographical regions. However, the marking technique used in this study should provide more accurate population estimates since the exact number of flies marked was known and the recapture rates were greater in comparison with the estimated number of flies marked and released in the study of Harlan and Roberts (1976).

CHAPTER V

SUMMARY AND CONCLUSIONS

During 1982 and 1983, 45,153 T. abactor were marked and released with a mean recapture rate of 6.12%. The recapture rates achieved in this study were almost two times those reported by other researchers using tabanid mark-recapture techniques. This study was the first to compare recapture rates for both engorged and nonengorged tabanids.

The number of engorged flies marked totaled 8,238 and 11,583 with recapture rates of 9.18 and 8.94% for 1982 and 1983 respectively. Marked nonengorged flies totaled 9,115 and 16,217 with recapture rates of 5.11 and 3.11% for 1982 and 1983 respectively.

Engorged flies were recaptured in greatest numbers on days three (38.63%) and four (24.12%) post-release which correlates with the 72-96 hr feeding cycle of T. abactor. Nonengorged flies were recaptured in greatest numbers on days one (25.16%) and two (21.44%) post-release. Dispersal of the engorged flies was the same as that of the nonengorged flies once the blood meal had been digested.

The number of marked flies recaptured decreased with increasing distance from the release site. Over 86% of all recaptured flies were captured in traps located at 0.4 and 0.8 km. However, marked flies were recaptured up to 2.4 km from the release site. Engorged flies were recaptured in largest numbers at 0.4 km while the engorged flies were recaptured at 0.4-0.8 km.

In 1982, comparison of traps placed at the woods' edge and in the open field revealed that 65% of all marked flies recaptured were trapped at the woods' edge as were 60% of all unmarked flies. It can be concluded that dispersal of T. abactor occurs more readily along the woods' edge than across open areas. The collection of the large percentage of unmarked flies in this habitat may also indicate that this habitat is also the site of oviposition and larval development of this species.

Population estimates were based on the number of flies marked, marked flies trapped and estimated marked flies remaining in the population. The population estimates were first calculated by the method of Harlan and Roberts (1976) for both the marked, engorged and nonengorged groups. Since the number of marked flies recaptured each day varied greatly between the engorged and nonengorged groups, a weighted mean was then used to calculate the daily population estimates. In 1982, a mean of 529,047 host-seeking T. abactor per day was estimated in an area of 2.1 km^2 from 26 June to 27 July. In 1983, the mean daily population estimate was ca. 5,003 flies for an area of 4.6 km^2 from 1 July to 7 August. Assuming a 1:1 ratio of male to female flies, the mean daily population estimate would have been ca. 1,058,094 and 1,690,006 flies for 1982 and 1983 respectively. Seasonal fluctuations of the populations were similar for 1982 and 1983.

The population estimates calculated in this study are probably more accurate than those reported by Harlan and Roberts (1976) since the marking technique provided an exact record of the number of flies marked and released in contrast with the estimated number of flies marked and released by Harlan and Roberts (1976). This study did not attempt to estimate the entire population of *T. abactor* on any given day but only the number of host-seeking flies. Thus, the total female populations of this species would be even greater than the estimates calculated in this study. Since *T. abactor* did not disperse much beyond 0.8 km from the site of release, it appears feasible that a smaller sampling area with a greater concentration of traps per unit area would provide the most accurate data for estimating populations of this species.

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VITA 2

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